GENERAL & DESCRIPTIVE
ANATOMY
OF THE
DOMESTIC ANIMALS

BY

JOHN GAMGEE & JAMES LAW

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PLATE I

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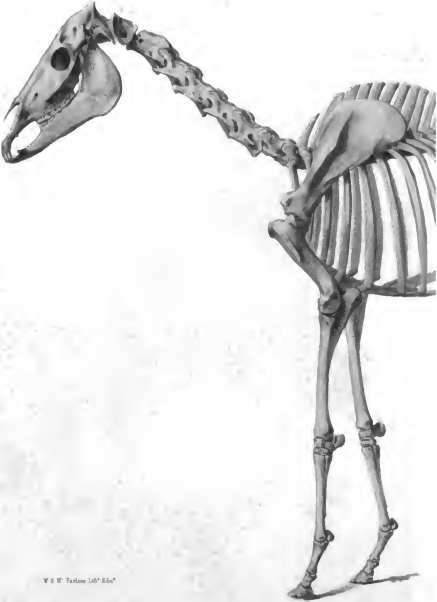

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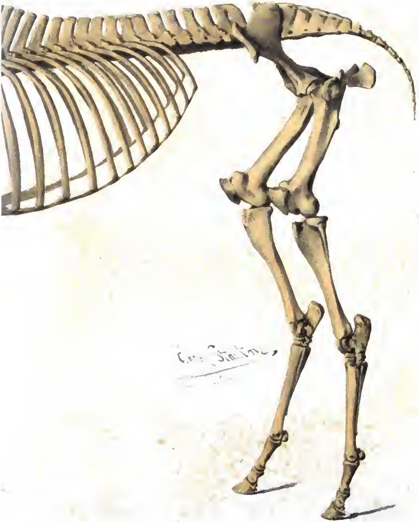

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DOMESTIC ANIMALS.

BY

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DEDICATION.

MY DEAR PROFESSOR SYME,

In gratitude, and in commemoration of the potent influence used in behalf of the New Veterinary College at the period of its decisive struggles, I venture to inscribe this work to you.

No one can afford more striking proof than yourself how essential a perfect knowledge of Anatomy is, to attain excellence in the Healing Art. That this work may help to train some minds and hands in accordance with the system that has rendered Edinburgh illustrious for a SYME and a GOODSIR, is the earnest wish of,

MY DEAR PROFESSOR SYME,

Yours ever obliged,

JOHN GAMGEE.

NEW VETERINARY COLLEGE,
EDINBURGH, *9th September*, 1861.

PREFACE.

A WORK on the Anatomy of the Domestic Animals has been so much in request, and is such a real necessity for the veterinary student at the present day, that, at the conclusion of last winter's session, we determined to avail ourselves of all the material prepared during the course of several years, and make an effort to supply the desideratum in time for the opening of the winter session of 1861–62.

Whatever may be the defects of the treatise, they cannot be accounted for on the ground of haste or insufficient opportunities to do the subject justice. We have attempted to ensure conciseness and accuracy, even at the expense of style, and there is no work, British or Foreign, which could supply useful information, that has not been carefully consulted.

The plan of the work is that which we have deemed most adapted for the wants of the veterinary student, and the subject has been treated on a comprehensive basis. The first part, devoted to General Anatomy, is simply introductory to the science of which it treats, as many details are introduced when special parts and organs are considered, and their structure can be appropriately described. The great changes which a few years have made in opinions regarding the nature of tissues, have rendered our task not an easy one; but in avoiding all that might be regarded as at all superfluous in an anatomical work, we have only enlarged on the most probable and most recent views regarding the constitution and development of animal textures.

An important feature in this, as in all works on anatomy destined for the student, consists in the illustrations, and these are in great part original—that is to say, drawn expressly for this work—whereas others are casts from the admirable engravings furnished in Professor Leyh's *Anatomy*.

We have occasion to be grateful for the facilities afforded us by scientific friends in this country, and abroad, in obtaining electrotypes of good woodcuts, the sources of which are acknowledged in the text. Some of the drawings engraved for this treatise were made by one of us in 1854, in Lyons, and were used by our esteemed friend, M. Chauveau, whose work on the Comparative Anatomy of the Domestic Animals may be declared the best treatise on veterinary anatomy, with the exception, perhaps, of Professor Leyh's.

We must specially acknowledge the assistance derived from Mr Clark Stanton and Mr A. T. Brett, in making many drawings. Both these gentlemen have a knowledge of anatomy specially fitted to render their delineations of anatomical subjects most faithful.

We have, in conclusion, to acknowledge great assistance from notes left by Dr Albert Monastier, late lecturer on anatomy in the New Veterinary College, who contemplated publishing such a work as this at the time that the Italian war called him to serve his country, and fight for its independence.

INTRODUCTION.

Definition of Anatomy.

THE Science of Anatomy is devoted to the study of animal organisation, and includes the knowledge acquired of form, relation, and structure of parts, as revealed by dissection.

General Anatomy.

Histology and Microscopic Anatomy.

There are several branches of this science, or rather Anatomy is studied for a variety of purposes. One investigates the elements found in common in every part, devotes his attention to the 'formative material,' out of which all tissues are constructed, and, in fact, reduces the apparently heterogeneous organism into one living substance, which acquires a peculiar form and special properties in different parts or organs of the body: that is the General Anatomist—the Histologist of the Germans. Microscopic Anatomy is only one division of General Anatomy, as a very important section of this study consists in the investigation of the characters or physical properties of tissue with the unassisted eye.

Descriptive Anatomy.

The Special Anatomist, or Descriptive Anatomist, has usually in view the acquisition of knowledge as applied to medicine, and devotes his attention to the careful examination of parts in their relation to each other for surgical purposes, or to the study of organs individually and collectively, to aid him in determining their healthy functions, with a view to appreciate the nature of disease.

Morbid Anatomy.

A sound knowledge of General and Descriptive Anatomy is required, to be proficient in Pathological Science; one important section of which is Morbid or Pathological Anatomy, or the study of tissues and parts in a diseased state.

Comparative Anatomy.

The Comparative Anatomist devotes himself to Anatomy with the single purpose of demonstrating the fundamental laws which govern animal form. He should study every creature with as much minuteness as the Human or Veterinary Surgeon studies one or two, and then compare individual parts or systems of organs, &c., in order to detect their universal plan of construction. Such a man deserves the title of the Philosophical Anatomist.

Biology.

Comparative Anatomy and Comparative Physiology, including the collateral sciences essential for their acquisition, are combined in the Science of Biology, or the Science of Life.

Veterinary Anatomy.

The Veterinary student must be impressed with the fact, that he cannot attain a correct knowledge of his profession, without acquiring great accuracy as a Descriptive Anatomist; without a knowledge of General Anatomy, and indeed without fully appreciating the facts, so far as brought out by our ablest Comparative Anatomists, regarding the simplicity, and yet infinite variety of form observed in the animals we call domestic. All this, we should say, is included under the single head Veterinary Anatomy.

Literature of Veterinary Anatomy.

Veterinarians in this country have not contributed much to the literature of their special Anatomy. Stubbs, an artist, published a most able work, illustrated by beautiful plates, in the year 1766. All know Mr Percivall's treatise, devoted to the anatomy of the horse; a most praiseworthy production, for which our students will ever be grateful. Without further detail, we shall here reproduce, from Professor Leyh's Treatise, the list of works either specially devoted to Veterinary Anatomy, or containing useful information on the subject:—

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GENERAL ANATOMY.

ANIMAL TISSUES.

THEIR CLASSIFICATION.—WHAT IS THE ULTIMATE ACTIVE ELEMENT OF A LIVING BODY?

Definition of a tissue.

An animal tissue is a material characterised by a special form, a complex chemical constitution, and endowed with vital properties subservient to the necessities of an organised being; the same tissue presents modifications in appearance, and though fundamentally similar in different parts, has been recognised by different names. The recognition of these differences, and the investigation of common characters, led Bichat to classify the structures of an animal into *similar* and *dissimilar*. But, with progress in the study of General Anatomy, classifications have been suggested more in accordance with the facts ascertained; and though imperfect, we are approaching a simplicity beyond which it will, perhaps, not be desirable to go.

Bichat's classification.

Enumeration of textures.

Some writers on General Anatomy have felt satisfied with a simple enumeration of the textures. They are:—

Epidermic tissue, including epithelium, cuticle, horn, hair, and nails.
Pigment.
Adipose tissue.
Connective tissue.
Fibrous tissue.
Elastic tissue.
Cartilage, and its varieties.
Bone.
Muscular tissue.
Nervous tissue.
Blood-vessels.
Absorbent vessels and glands.
Serous and synovial membranes.
Mucous membranes.
Skin.
Secreting glands.
Vascular or ductless glands.

Animal fluids.

The animal fluids include lymph, chyle, and blood, besides secretions or the products of glands, such as saliva, bile, urine, &c.

In the foregoing list several tissues are mentioned which belong as much to connective tissue, as horn or hair deserve the name of epidermic textures. Muscle and nerve are alone distinct from their special characters and endowments from the epidermic and connective tissue. The blood-vessels, absorbents, membranes, skin, and glands are compound organs or structures, which are themselves composed of the materials mentioned above them. Dr Lionel Beale* says:—"The class of 'connective' tissues has now become so large that there may be doubt in the minds of some as to the utility of a classification which divides all the tissues of the body into three classes; the first of which includes but one tissue—*epithelium;* the second, only two—*muscle and nerve;* while the third—*connective tissues*—comprehends three times as many as are included in the two first classes; and while continuity of texture has been used as an argument for including numerous textures under the head of connective tissue, this continuity has been demonstrated to exist between certain tissues included in the two other classes with those of the connective tissue group." Moreover, Dr Beale says, "that a nerve-fibre may become converted into a form of connective tissue; and hence, according to this classification, a tissue which at one period of its existence finds a place in one class, must be included at another period in a totally different class."

Cells.

Dr Beale's views.

There is a common structure which appears intermediate between the shapeless animal matter, out of which tissues are formed,—"blastema," "cytoblastema," and the perfect tissue, which is composed of objects termed "cells." According to Beale's view, the pabulum coming in contact with *living matter* (germinal matter), becomes endowed with the same powers, and after passing through certain definite stages of existence, it assumes the form of tissue. The cell is regarded by some as the one elementary structure from which all tissues spring. It is described as composed of a wall or envelope, *a* (Fig. 1); cell-contents, *b*; a nucleus, *c*, which, in some instances, is absent, and in others is observed to contain small particles, nucleoli, *d d*.

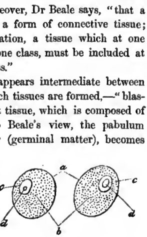

Fig. 1.

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* I have to acknowledge Dr Beale's kindness, in favouring me with proofs of his lectures on this interesting subject before the publication of his important work.

Professor Goodsir long since said:—"The centre of nutrition with which we are most familiar, is that from which the whole organism derives its origin—the germinal spot of the ovum. From this all the other centres are derived, either mediately or immediately; and in directions, numbers, and arrangements, which induce the configuration and structure of the being. As the entire organism is formed at first, not by simultaneous formation of its parts, but by the successive development of these from one centre, so the various parts arise each from its own centre, this being the original source of all the centres with which the part is ultimately supplied.

Goodsir on centres of nutrition.

"From this it follows, not only that the entire organism, as has been stated by the authors of the cellular theory, consists of simple, or developed cells, each having a peculiar independent vitality, but that there is, in addition, a division of the whole into departments, each containing a certain number of simple or developed cells, all of which hold certain relations to one central or capital cell, around which they are grouped. It would appear, that from this central cell all the other cells of its department derive their origin. It is the mother of all those within its own territory. It has absorbed materials of nourishment for them while in a state of development, and has either passed them off after they have been fully formed, or have arrived at a stage of growth when they can be developed by their own powers."

Virchow[*] says:—"Especial difficulty has been found in answering the question, from what parts of the body action really proceeds,—what parts are active, what passive; and yet it is already quite possible to come to a definite conclusion upon this point, even in the case of parts the structure of which is still disputed. The chief point in this application of histology to pathology, is to obtain a recognition of the fact, that the cell is really the ultimate morphological element in which there is any manifestation of life, and that we must not transfer the seat of real action beyond the cell."

Virchow on cells.

Dr Bennett, on the other hand, would wish us to go beyond the cell, and says:—"The first and last element is, as regards form, the molecular. Organic formative fluids deposit molecules, which arrange themselves, subject to vital laws, into nuclei, cell-walls, and higher textures. These, once produced, subsequently decay in an inverse order, breaking down into individual fragments, and ultimately into

The molecular theory.

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[*] *Cellular Pathology, as based upon Physiological and Pathological Histology.* By RUDOLPH VIRCHOW. Translated by FRANK CHANCE, B.A., M.D., Cantab. London, 1859.

minute molecules. During the whole life of an individual organism, we observe in it a constant series of these formations and disintegrations—of these histogenetic (formative) and histolytic (destructive) actions."

Dr Beale's views.

Dr Beale, on the other hand, maintains with Virchow, that living molecules cannot be *deposited* from a fluid, but that they come from pre-existing living matter. He refers to the smallest elements which may be termed living, in the following terms:—"When we attempt to examine the structure of the simplest forms of living beings, we cannot but regard the extreme minuteness of many independent organisms which live, and grow, and increase their kind, with the utmost astonishment. We shall scarcely be able to realize this minuteness at all. When I watch the appearance of minute organisms in water containing a little dead animal or vegetable matter, I feel sure that many of the living particles were in existence some time before they had grown large enough for one to see them with the highest power I have been able to obtain (1700 diameters, made by Messrs Powell & Lealand.)"

Differences between the three theories.

The differences between the three theories are:—1st, As to the origin of animal tissue. Dr Bennett and others believe, that from an animal fluid particles develop and aggregate to form cells, and these develop into tissues. Virchow believes all to begin from a cell, and the result of productive power enjoyed by the latter, whereas Dr Beale* holds that the elementary part (cell) of every living structure consists of matter in two states—*germinal matter* or *living matter*—which came from living matter, and which may produce new living matter, and *formed material*. The latter corresponds to the 'cell-wall,' or 'intercellular substance.' This has ceased to be active, cannot give rise to new matter, but in it alone all the characteristic properties of tissues reside. He believes "that the smallest living particles of all living beings are spherical, and are composed of spherical particles *ad infinitum*. The inanimate matter passes into the spherical particles, and there becomes endowed with their wonderful powers—in fact, becomes living. The living spherules move in a direction from the centre towards the circumference of each spherule to which they belong. This tendency to divide is due to the same force which compels them to move constantly *from* the centre where they became living. Each particle is preceded by those which became living before it, and succeeded by others which were animated since it commenced to exist. This movement outward occurs in the living particles of all living beings, and its rapidity determines the rate at which the structure grows." This view of the nature of the changes occurring in the particles of living matter differs entirely from those generally held. Dr Beale would explain the whole matter by this movement of the particles from centres, and their passing through certain definite phases or stages of existence.

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* *Archives of Medicine.* April, 1861. Page 227.

Law of continuous development.

The law of continuous development thus enunciated by Dr Beale* has been differently expressed by Virchow. He says:—"At the present time, neither fibres, nor globules, nor elementary granules, can be looked upon as histological starting-points. As long as living elements were conceived to be produced out of parts previously destitute of shape, such as formative fluids, or matters (*plastic matter, blastema, cytoblastema*), any one of the above views (referring to theories of cell-development) could of course be entertained, but it is in this very particular that the revolutions which the last few years have brought with them has been the most marked. Even in pathology, we can now go so far as to establish, as a general principle, that *no development of any kind begins de novo,* and consequently as to reject the theory of equivocal (spontaneous) *generation, just as much in the history of the development of individual parts as we do in that of entire organisms.* Just as little as we can now admit that a tænia can arise out of saburral mucus, or that out of the residue of the decomposition of animal or vegetable matter an infusorial animalcule, a fungus, or an alga, can be formed—equally little are we disposed to concede, either in physiological or pathological histology, that a new cell can build itself up out of any non-cellular substance. Where a cell arises, there a cell must have previously existed *(omnis cellula e cellula),* just as an animal can spring only from an animal, a plant only from a plant. In this manner, although there are still a few spots in the body where absolute demonstration has not yet been afforded, the principle is nevertheless established, that in the whole series of living things, whether they be entire plants, or animal organisms, or essential constituents of the same, an eternal law of *continuous development* prevails. There is no discontinuity of development of such a kind that a new generation can of itself give rise to a new series of developmental forms. No developed tissues can be traced back either to any large or small simple element, unless it be unto a cell." This is what Virchow calls the *proliferation of cells.*

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* Dr Beale states that the following general conclusions seem to be justified by the appearances observed in specimens he has prepared:—

"The elementary parts of the tissues of every living being consist of an active, living, growing substance, *germinal matter*, and of *formed material* resulting from this. The *germinal matter*, in all cases, when examined by the highest powers, is seen to be composed of spherical particles, but its powers are wonderfully different in different beings. It possesses in all cases the power of infinite growth. It is always coloured red, not merely stained, by an ammoniacal solution of carmine. The *formed material* differs remarkably in characters and properties in various tissues and living beings, and the difference depends mainly upon the powers of the germinal matter which produced it. It may be stained with carmine, but it is not coloured like the germinal matter. The whole of the germinal matter is not converted into formed material, but a small portion (nucleus) remains, perhaps, for a very long time in a quiescent state. From this, new centres of growth may proceed infinitely, even if the whole of the germinal matter, undergoing active change, is destroyed.

"*Development* consists essentially in the production of successive elementary parts, the formed material of each series becoming a higher and more perfect tissue than that of its predecessors.

"*Growth* depends upon a greater number of elementary parts being produced than is required merely to make up for those which are removed.

"*Nutrition* is the conversion of pabulum into germinal matter, at a rate and in quantity exactly sufficient to replace the amount of germinal matter converted into *formed material*, and this corresponds to the proportion of the latter which is removed, or decays, or is converted into soluble substances.

"*In decay*, the oldest part of the formed material having lost its characteristic properties, and no longer capable of resisting the action of destructive agents, is soon resolved into simpler compounds, which are removed, and in part, at least, again taken up by living particles.

"Every living particle comes from a pre-existing living particle. There is reason to believe that independent living particles exist, which are infinitely smaller than the smallest particle which can now be seen by the highest powers yet made (1700 diameters)."

Proliferation of cells.

Essential constituents of a cell.

But there is a second point of great difference, brought out by Dr Beale's observations, and that is, as to the necessary or essential constituents of a cell. Dr Beale says:—"According to the generally received theory, the cell-wall is considered a most important structure, but it does not exist constantly. There is a very large class of the lower animals from whose bodies protrusions may be formed in different parts, and their protrusions may meet here and there. Where they touch, they coalesce. Clearly, then, there can be no investing membrane here; neither is a living structure of this kind confined to the lower animals. It exists in man himself. I have seen such protrusions from mucous particles both from the nose and also the bronchial tubes, under a power of 1700 diameters. A portion of the mass slowly extends itself outward; perhaps three or four such outgrowths may be seen in different parts of the mass. If detached, they assume the spherical form: but if two come into contact they coalesce. These movements only lasted for a minute or less, after the mucus was transferred to the glass slide. Protrusions may be often observed to occur from the white blood-corpuscles, and in rare cases, the red blood-corpuscles adhere so intimately to each other, that it is difficult not to believe that the outer part of their walls consists of a soft viscid matter which runs together when several come into contact. It is clear, therefore, that the cell-wall is not a constant structure, and that living organisms and elementary parts of living organisms may exist without it."

Virchow on the essential elements of a cell.

A cell is regarded by Virchow as having for its essential element a membrane or envelope, and that which is within the cell or cell-contents, as subject to variation according to the circumstances under which the cell is placed. "It is only," says Virchow, "when we adhere to this view of the matter, when we separate from the cell all that has been added to it by an after-development, that we obtain a simple, homogeneous, extremely monotonous structure, recurring with extraordinary constancy in living organisms. But just this very constancy forms the best criterion of our having before us in this structure one of these really elementary bodies, to be built up of which is eminently characteristic of every living thing, without the pre-existence of which no living forms arise, and to which the continuance and the maintenance of life is intimately attached."

Dr Beale on cell-action.

Dr Beale considers the processes which are ordinarily termed 'cell-growth,' 'cell-action,' consist simply in the movement of living particles *from* centres which causes the pabulum to flow *to* the same centres. The oldest portion of each living particle is *outside*, and the matter which has only just become living, in the *centre*. The oldest particles may be converted into cell-wall, fibrous tissues, soft mucus, or resolved by the action of oxygen into substances which are at once removed in a soluble or in a gaseous form. This is *formed material*. Dr Beale, therefore, speaks of an elementary living structure as consisting of matter in two states—*germinal matter* and *formed material*, instead of using the terms *cell-contents*, *cell-wall*, *intercellular substance*, &c., which have a different signification, and possess different properties in different cases.

Spontaneous development.

The theories of spontaneous development cannot, in our opinion, stand; and the law of continuous growth or development must be

Molecular theory.

admitted. We do not believe in the molecular theory, however plausible the arguments in its favour. In answering the question, What is the ultimate living element of an animal? we can only go so far as to say that such an element must be proved to manifest the properties which are termed vital, and which are readily demonstrated in the cell, although Dr Beale tries to show that they exist quite as distinctly in the minute particles which he has examined by the new and powerful lenses for which science is indebted to Messrs Powell and Lealand. There is less to take for granted in accepting Dr Beale's view than Professor Virchow's; and we think that, for anatomical purposes, it is sufficient to declare that all tissues can be traced to a primitive cellular form—that the cell or elementary part is undoubtedly an aggregate of living particles, surrounded with a substance in a less active or entirely inactive state, which often only serves the part of a protective covering. The importance of the living particles in nutrition, growth, and reproduction, may be quite as great as Dr Beale believes.

The cell-wall.

With regard to the formation of the outermost structure, usually termed the *cell-wall*, it will be observed that Dr Beale's views differ essentially from those generally entertained. It is considered that this structure is formed by deposition from without, so that the other constituents of the cell are enclosed by it. Dr Beale tries to show that it is, so to say, merely the result of the life of the particles within. He supposes that the oldest of these become altered, and thus this matter is formed. He goes so far as to say that the whole of the intercellular substance was once in the state of germinal matter; or, in the usual phraseology, was *cellular*. If these views are confirmed, our notions of structure will be very much simplified.

SIMPLE FORMS OF ANIMAL MATTER.

Whatever may be the fact as to the nature of the ultimate element which is endowed with the powers of growing and reproduction, it is certain that, in examining tissue, we observe a number of simple objects which may be said to compose the textures, and on which their peculiarities in a measure depend. These objects are molecules, globules, fibres, simple membrane.

Molecules.

I. Molecules or granules are infinitely minute, are probably always spherical objects, which exist within cells or in the intercellular tissue. Floating in a liquid in the field of the microscope, they move in pairs, backward and forward, with great activity. These are the Brunonian molecular movements, named after Robert Brown, who drew special attention to them. Molecules may be fatty, albuminous, pigmentary, amylaceous, and earthy. The differences between these are distinguished partly by re-agents and partly by colour: it is thus that pigment is recognised, A few drops of ether will dissolve fatty, but not the albuminous or earthy molecules. Acids will cause effervescence and solution of molecules composed of an earthy carbonate, and the solution will occur without effervescence in the case of phosphatic salts, in a molecular form.

Amyloid bodies.

Amylaceous, or starch granules, *corpuscula amylacea*, which are recognised by turning blue on the addition of iodine, have been found in many animal structures of late years, and approach the characters of ordinary starch granules. As Kölliker says:—"All these granules are destitute of the phenomena which are observed in the higher elementary parts, as of growth from within outwards, of multiplication, of taking up and giving off material, and are, in so far, still very closely allied to the purely inorganic forms.

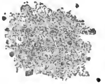
Fig. 2.

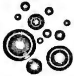
Fig. 3.

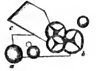

Fig. 4.

Fig. 2. (Beale.)—Granules, consisting of fatty matter, in a state of very minute division, from chylous urine, resembling the "molecular" base of the chyle. Small cells are also observed, × 215.

Fig. 3. (Beale.)—Air-bubbles of various sizes in water, × 215.

Fig 4. *a*. Spherical refrangent globules of phosphate of lime. *b*. The same indicating their solidity by cleavage. *c*. Crystals of cholesterine.

Globules.

II. Fatty molecules aggregate and form elementary vesicles, to which is commonly applied the term of globule. The globules vary greatly in size, and have a special appearance, due to the manner in which they refract light (Fig. 2.) The brightly refrangent fat globules are readily recognised, though other objects may be occasionally taken for them. Thus, air-bubbles (Fig. 3) are frequently by the inexperienced mistaken for fat particles, and on one occasion I was much perplexed by the form and strong refractive powers of phosphate of lime globules (Fig. 4, *a*) which could only be recognised as earthy, and not fatty, by squeezing so as to cleave them (Fig. 4, b), and by the use of hydrochloric acid, which dissolved them entirely. These elementary vesicles may be seen in milk, in which, according to Henle, they are composed of fats with an envelope of casein. Mülder states that the small molecules of chyle and blood are fatty, with a proteine envelope. Ascherson indicated, in 1840, the fact, that by shaking oil and albumen together, vesicles resulted of the oil, enveloped by albumen; and Wittich has shown that this depends on a part of the fat being saponified by the alkali combined with the albumen, by these means the latter is solidified immediately on contact with the oil. Harting regards the process as a purely physical one, occurring between quicksilver and albumen and in shaking the latter with water or other fluid. Kölliker says:—"It will scarcely be necessary to assume the presence of chemical influence when, by mixing together albumen and chloroform, you produce albumen membrane; by mixing casein of serum and fat, caseine membrane; and by mixing chondrine and chloroform, chondrine membrane, as has been observed by Panum."

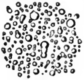

Fig. 5.

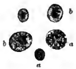

Fig. 6.

Fig. 5. (BEALE.)—Milk globules, × 215.
Fig. 6. (BEALE.)—Globules, *a a*, and granules, *b b*, enclosed in cells.

Fibres. III. Fibres.—The simple fibre is often the result of the elongation and coalescence of cells as in connective tissue; but in many structures termed fibrous, the appearance of fibres is probably due to a character assumed by membrane folded on itself. Fibres are occasionally compound structures, as termed by microscopic anatomists. Thus a muscular fibre is composed of a mass of fibrils.

Simple membrane. IV. Simple membrane.—A clear and perfectly homogenous layer of animal matter of extreme tenuity ($\frac{1}{30000}$th of an inch in thickness or less), is called a simple membrane. It forms the envelop of cells, the walls of the minutest vessels, and the intervening tissue between a mucous membrane or skin and the epithelium or cuticle above it. The terms basement or limitary membrane have been applied to the delicate expansion in the last-named situation.

Crystals.

V. Crystals and crystalline granules hold a subordinate position as elements of animal tissue. They are met with in secretions, in calcareous depositions, and in pathological formations of very varied character.

Fig. 7.
Granules of urate of ammonia.

CELLS.

Animal cells are so constantly under the eye of the microscopist, that a perfect knowledge of the circumstances which produce an infinite variety of peculiarities is indispensable. Cells either flatten or elongate; they are pressed into polygonal shapes, or coalesce and form tubes. They occasionally swell, and many materials, especially fats and colouring matters, enter in their interior. We here use the term 'cell,' regardless of any theory as to its nature, in the same sense as Dr Beale employs the term 'elementary part,' consisting of 'germinal matter' and 'formed material,' as much as objects unmistakeably cellular.

Cell-changes.

We believe, with Virchow, that the history of cell-changes in progressive development includes the history of the formation of all the animal tissues, so that it is impossible to exhaust this subject without furnishing all known details in microscopic anatomy. A general history of the more common changes is, however, important, and we may refer to Dr Sharpey's classification of this subject. He refers, 1stly, to their increase in size and change of figure; 2ndly, to alterations of substance and of contents; 3rdly, to their division into fibrils; 4thly, to changes in the relation of cells to each other; 5thly, changes in the nuclei of cells.

Increase in size.

I. Increase in size and change of figure.—Cells grow by the imbibition of nutrient matter which is assimilated. The number of cells rapidly increases as well as their size, and as they close in upon each other they become flattened, prismatic, angular, or polyhedral. Round cells, in developing tissue, elongate and often radiate into star-shaped objects, the branches of which coalesce.

Change in substance.

II. Alteration of substance and of contents.—Dr Beale indicates by the immersion of cells into an ammoniacal solution of carmine, how, as they become perfect, the formed material which is external escapes being coloured, whilst the nucleus and germinal matters around it are deeply tinged. From centre to circumference there is therefore a remarkable change of substance, which has been noticed to affect layers of cells, progressing from the deepest to the more superficial. Thus in the case of cuticle, the deeper cells are soluble in acetic acid, and the superficial are not. Dr Beale concludes that growth always takes place from centre to circumference, and that in any case the *outermost* part is the *oldest*.

The contents of cells often change by mere chemical action, and it is to this that we are inclined to attribute the frequent appearance of oleine in the substance of cells which are undergoing retrograde changes, or, in other words, which are in a process of destruction, that their material may be absorbed. Such is evidently the change in pus globules before pus can be absorbed. Dr Beale attributes this to the death and subsequent changes of the particles. There may be addition or substitution of material constituting the cell-contents, as in the secreting or spheroidal cells and pigment.

"As in plants, too, the new substance may be so deposited as to augment the thickness and strength of the cell-wall, of which an example occurs in the thickening of the sides and narrowing of the cavity of cartilage-cells by layers of new matter on their internal surface. According to Henle, the deposit sometimes occurs on the outer surface of the cell-wall; or the process may assume still more of a plastic and organizing character, as in the endogenous production of young cells already described, and the formation of the spontaneously moving bodies named spermatozoa or spermatic animalcules, which, in plants as in animals, are produced in the cavity of a cell." —(SHARPEY.)

Division.

III. Division into fibrils.—We believe with Virchow that this does not occur in the development of tissue, though Schwann believed that the delicate fibres of white fibrous tissue were produced by the splitting up of cells. It is true, however, that one exception may be made in favour of ciliated epithelium, the hair-like appendages of which are probably due to a splitting up of the cell at its edge.

Changes of relation.

IV. Changes in the relation of cells to each other.—These are very numerous. They chiefly consist in coalescence in different ways. Firstly, By the arms of stellate cells joining. Secondly, By simple agglutination. Thirdly, By an intercellular substance, as in cartilage; and, Fourthly, by rows of cells uniting, and their parietes becoming absorbed at the part of contact, so as to form a hollow tube out of each row.

Changes in nuclei.

V. Lastly, The nuclei of cells may undergo changes.—Indeed, it would appear that within them exists a latent vitality, not witnessed in the constituents of the cell approaching the cell-wall, and the multiplication of cells is often due to the subdivision of their nucleus. The nucleus not unfrequently disappears when a cell grows old.

TISSUES COMPOSED OF CELLS ALONE.

EPIDERMIC TISSUE.

Epidermis.

On all surfaces, whether of the skin, mucous, serous, or synovial membranes, layers of cells, are disposed, either for the purposes of protection, or to perform an office in connection with the function of the membrane on which they are found. Thus situated, the layers of cells constitute epithelium, on mucous and serous membranes—cuticle or epidermis on the skin.

It is the constantly recurring animal cell, described as lymph-cell, spheroidal cell, gland-cell, &c., which undergoes various changes in the production of the different kinds of epithelium. There is a gradual transition from the textures on which epithelium is found to the simple cellular covering; and this we have long since seen from the elongated and so-called fibro-plastic cells, mingled with the tesselated epithelium of serous membranes.

Cuticle or epithelium is not vascular, not sensitive, and is constantly nourished from the vascular surface it covers, the newly-formed cells displacing the older ones.

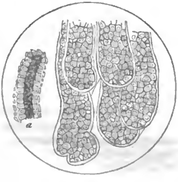

Fig. 8. (DALTON.)—Gastric tubules from pig's stomach, pyloric portion, showing their cæcal extremities. At *a*, a cylindrical cast of epithelium, pressed out from a tubule, showing the size of its cavity.

Spheroidal epithelium.

I. SPHEROIDAL EPITHELIUM.—TISSUES OF GLANDS.—The saccular or tubular recesses of glands where secretions are constantly accumulating and elaborated, contain a large quantity of spherical cells, nucleated and slightly granular, always very transparent, and usually manifesting a tendency to the polyhedral form from their pressure on each other. When floating in the field of the microscope they are always spheroidal, but they may be seen within glands assuming various forms, as in Fig. 8.

Fig. 9 represents spherical cells from the pancreas, and similar ones may be seen in the sweat glands, salivary glands, liver, kidneys, testicles, &c.

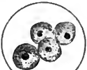

Fig. 9.—Spheroidal cells from the pancreas of sheep.

Goodsir on secreting cells.

The peculiar influence exerted by these cells in the function of secretion has been recognised by Professor Goodsir, and others, as of great importance. Mr Goodsir says: "Secretion is a function of the nucleated cell;" and further on he says, "The ultimate secreting structure, then, is the primitive cell, endowed with a peculiar organic agency, according to the secretion it is destined to produce." Professor Goodsir also adds that "each primary secreting cell is endowed with its own peculiar property, according to the organ in which it is situated. In the liver it secretes bile, in the mamma, milk, &c."*

Kölliker on gland tissue.

Kölliker refers to this epithelium under the head 'Tissue of glands,' the secerning elements of the latter being polygonal or cylindrical cells which "completely resemble certain epithelial cells," and "characterised by peculiar contents." By the co-operation of homogeneous membranes, vessels, and nerves connected by areolar tissue, with elastic and muscular fibres, different glands are produced, and Kölliker mentions the chief forms of secerning glandular elements as—

1. *Solid cell net-work, without rudiments of an investing membrane.* In the liver.

2. *Shut vesicles, with a fibrous coat and an epithelium.* Graafian vesicles of the ovaries; follicles of the thyroid. The thymus, which consists of a common cavity, beset with numerous vesicles, perhaps belongs to this division.

3. *Open, roundish, or elongated glandular vesicles, with a membrana propria and an epethelium.* In the racemose glands.

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* *Anatomical and Pathological Observations.* Edinburgh, 1845.

4. *Open, glandular tubes, with a membrana propria, or a fibrous coat, and an epithelium.* Tubular glands (Fig. 8).

The following is Kölliker's classification of true glands, which applies to the domestic animals as much as to the human body:—

1. *Glands with short vesicles,* which burst occasionally, or remain constantly shut. Ovaries, thyroid.

2. *Glands whose parenchyma consists of reticulated cells.* Liver.

3. *Racemose glands,* in which collections of roundish or elongated, vesicles are seated upon the ultimate terminations of the excretory ducts.

(*a*) *Simple,* with one, or few lobules. Mucous glandules, sebaceous glands, meibomian glands.

(*b*) *Compound,* with numerous lobules. Lacrymal glands, salivary glands, pancreas, prostate, Cowper's and Bartholine's glands, mammary glands, lungs.

4. *Tubular glands,* whose secerning elements have the form of tubes.

(*a*) *Simple,* consisting of but one, or some few tubes, terminating in blind extremities. Tubular, gastric, and intestinal glands, uterine glands, sudoriferous and ceruminous glands.

(*b*) *Compound,* with numerous branches, and, perhaps, reticularly united canals. Testicles, kidneys.

Office of cells in secretion.

We rather incline to the belief that cells, immersed in the fluid which transudes from the blood-vessels in the recesses of glands, become impregnated by materials which undergo change from being retained within the cells, and as these are forced onwards they burst, and their contents become characteristic elements of the secretion peculiar to the gland whence it is derived. There are many points to be considered when we compare different glands and their secretions, which may operate in producing the differences observed in the latter.*

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* The importance of the epithelial elements in glands has been insisted on by Virchow, who says:—"The really active elements of these organs are essentially of an epithelial nature. One of Remak's greatest merits consists in his having shown that in the normal development of the embryo the outer and inner of the well-known three layers of the germinal membrane chiefly produce epithelial structures, from a gradual proliferation of the elements of which glandular structures arise. Other observers, for example, Kölliker, had indeed before him made similar observations, but by Remak was first established the law that the formation of glands in general must be regarded as consequent upon a direct process of proliferation on the part of epithelial structures. Previously large quantities of cytoblastema had been conceived to exist, in which, spontaneously,

Dr Beale's views.

In some instances, however, epithelium is engaged in a process of transformation. Dr Beale says:—" In *secretion*, the formed material is, I believe, gradually altered, and is at last resolved into the substances characteristic of the secretion. This process is much more rapidly effected in some secreting organs than in others. The end of the life of the particles of germinal matter of the elementary parts of the liver,

glandular substance took its rise; but, with the exception of the lymphatic glands, and perhaps those belonging to the sexual organs, their mode of origin is everywhere this—that at a certain point, in a manner very similar to that which I described to you in the foregoing lecture, when speaking of the excrescences of plants, an epithelial cell begins to divide, and goes on dividing again and again, until by degrees a little process composed of cells grows inwards, and, spreading out laterally, gives rise to the development of a gland, which thus straightway constitutes a body continuous with layers of cells originally external. Thus arise the glands of the surface of the body (the sudoriferous and sebaceous glands of the skin and the mammary gland), and thus also arise the internal glands of the digestive tract (the stomach-glands and liver). The most simple forms which glands can present do not occur at all in man. In inferior animals, however, *uni-cellular glands* have recently been discovered. The glands of the human body are invariably made up of a number of elements, which can, however, ultimately be traced back to a nearly simple type. Besides, in our own glands, in consequence of their size and complicated structure, other necessary constituents generally enter into their composition, so that, regarded as organs, they certainly do not consist of gland-cells only. But all parties are now pretty well agreed that the gland-cells are the really essential elements, just as the primitive bundles are in muscle, and that the specific action of a gland is dependent upon the properties and peculiar arrangement of these elements.

"Generally speaking, therefore, glands consist of accumulations of cells, which usually form open canals. With the exception of the glands whose functions are uncertain, such as the thyroid body and supra-renal capsules, there are in the human body only the ovaries which form an exception to this rule, inasmuch as their follicles are only open at times; yet they too must be open when the specific secretion of ova has to take place. In most glands there is found indeed besides a certain quantity of transuded fluid, but this only constitutes the vehicle which floats off either the cells themselves, or their specific products. Suppose, for example, that in one of the ducts of the testicle a cell, in which there is a production of spermatozoa becomes detached, then there transudes at the same time a certain quantity of fluid, which carries them away; but what makes the semen, semen, and constitutes the specific character of the action is the peculiar power of the cell; the mere transudation from vessels is no doubt a means of conveyance onwards, but does not constitute the specific action of the gland nor the real secretion. In an analogous manner, in all the glands of which we can follow the action in all its details with precision, the essential peculiarities of their energy are derived from the development and transformation of epithelial cells."

is the production of formed material, which is at length resolved into bile,—a substance easily converted into sugar,—and other compounds. As urea exists in the healthy blood, it may be that it is only separated and taken up by the elementary parts in solution in water. It is most likely, however, that the extractive matters, and some other constituents of the urine, and perhaps part of the urea, result from changes taking place in the formed material of the renal epithelium.

"The peculiarity of each secretion depends to some extent upon the state of the blood, but mainly upon the peculiar powers of the germinal matter, and these properties often differ in the most remarkable degree in animals closely allied to each other. The milk, for instance, of mammalian animals possesses certain characters which at once distinguish it from every other secretion. It contains, as is well known, a cheesy substance, a fatty and a saccharine substance, and saline matters, but these differ in their relative proportions and in some important qualities, in the milk of different animals. These differences depend upon the properties of the particles of germinal matter of the lacteal elementary parts which at length become resolved into the constituents of milk. As we have (so to say) certain generic and specific differences in the tissues of various animals, so also corresponding differences exist as to the chemical components of their bodies. We have in all, bile, and saliva, and gastric juice, and urine, &c., and in the blood we have albumen, and fibrin, and hæmatoglobulin. But the bile, saliva, and other secretions of different animals, possess well-marked differences, and of albumen and hæmatoglobulin there are certainly many kinds capable of being distinguished from each other by chemical and other tests. It is probable that we can, as yet, form but a very imperfect idea of the chemical changes which take place in, and the number of compounds which intervene between, a particle of food and the particle of tissue formed from it. These chemical substances may vary very slightly in composition and other characters, in animals nearly allied to each other, so that many varieties may be produced, all differing slightly from each other, but having certain characters in common which justify us in calling them all by one name."

Transitional epithelium.

II. TRANSITIONAL EPITHELIUM is composed of the spherical cells, undergoing a change in form near the parts where columnar or scaly epithelium exists.

III. COLUMNAR, PRISMATIC, OR CYLINDRICAL EPITHELIUM.—The

Columnar epithelium.

subjoined Fig. 10, after Henle, indicates the manner in which, by pressure, as the spherical epithelial cells advance in the ducts of glands they elongate, are agglutinated by an intercellular substance, and flattened from side to side. The nucleus and nucleoli are usually distinct about the middle of the cell. The pointed end is the one near the mucous membrane, and the spaces between the cells at this part are, according to Valentin, filled up by young cells in successive stages of advancement.

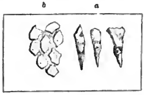

Fig. 10. (HENLE.)—Columnar epithelium. *a*, Columns of epithelium from the intestine magnified; *b*, Viewed by their broad free extremity.

This form of epithelium is found in the stomach, intestine, hepatic ducts, and gall-bladder, or indeed in all duct-glands.

An important character of columnar epithelium is referred to in the following terms by Dr Beale:—"Upon examining a cell of columnar epithelium from the intestine, it will often be observed that at its summit the cell-wall is considerably thickened. The appearance somewhat resembles that which would be produced by the presence of very fine cilia, but careful observation has proved beyond a doubt that it is not due to this cause. Kölliker has carefully investigated this subject, and has discovered very minute pores passing through the cell-wall, and apparently filled with granules of oil. It would seem that this is the manner in which the oily matter, mixed with the contents of the intestine, reaches the interior of the cell, where it accumulates until globules, often of considerable size, are formed. I have long been familiar with the appearance alluded to, and have observed the thickening, not only in the cells from the villi, but in other varieties of columnar epithelium." *

Fusiform epithelium.

IV.—FUSIFORM EPITHELIUM, made up of elongated cells, arranged side by side, as in arteries and veins.

Ciliated epithelium.

V. CILIATED EPITHELIUM.—The columnar and spheroidal cells, above described, present in certain situations vibratile filaments of great delicacy, termed *cilia*—hence the name applied to the form of epithelium thus endowed. There are many parts amongst the lower forms of animals which are provided with moving hair-like append-

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* *The Microscope in its Application to Practical Medicine.* By LIONEL BEALE, M.B., F.R.S. London, 1858.

Beard of mussel.

ages, for the purpose of inducing currents. Thus, a common object, favourable for microscopical demonstration, is the beard of a mussel. It is so difficult to obtain active ciliated epithelium, except from a nasal polypus, when just removed, or under other purely accidental circumstances, that we usually select structures from cold-blooded animals. Epithelium from the back of a frog's mouth answers the purpose admirably.

Microscopic characters.

If a small portion of mussel's branchiæ or beard is placed in the field of the microscope, and a drop of the salt water enclosed in the fresh shells is used for preparing the object, particles which are floating in the liquid may be seen rapidly moving in one direction, close to the beard under examination. Looking at the structure carefully, myriads of delicate cilia are seen moving so rapidly that, like the spokes of a wheel in active motion, they cannot be discerned separately. The movement, however, becomes slow in time, and the individual cilia are easily perceived with a lens which magnifies from 250 to 350 diameters. The motion is always in one direction, and in mammalia it is from the deeper parts to free openings.

From sheep's trachea

We here furnish a drawing of ciliated epithelium from a sheep's windpipe, and similar cells are seen in the nose, eustachian tubes, guttural pouches, tympanic cavity, frontal and sphenoidal sinuses, larynx (not the pharynx, which is covered by scaly epithelium), and continuous into the smallest bronchial tubes. Ciliated epithelium has been declared by Purkinje and Valentin to exist in the ventricles of the brain. It is also found in the uterus, Fallopian tubes, and on the fimbriated extremities of the latter.

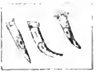

Fig. 11.—Ciliated epithelium from the trachea of a sheep.

Durations of ciliary movement.

It is said that ciliary movement may persist in warm-blooded animals as long as two days after death. It has been seen in a tortoise fifteen days after decapitation, continuing seven days after the muscles had ceased to be irritable.[*]

Heat and cold.

On the influences which affect ciliary motion, Dr Sharpey furnishes the following interesting resumé:—"The effect of change of temperature is different in warm and cold-blooded animals. In the former the motion is stopped by a cold of 43° F., whereas in the frog and

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[*] QUAIN's *Anatomy*. By Dr SHARPEY and Mr ELLIS. London, 1856.

Electricity. Fresh water. Acids and salts. Alkalies. Narcotics. Animal fluids.

river-mussel it goes on unimpaired at 32° F. E. H. Weber has made the interesting observation that in ciliated epithelium particles detached from the human nasal membrane, the motion which has become languid or quiescent from the cold, may be revived by warmth, such as that of the breath, and this several times in succession. A moderately elevated temperature, say 100° F., does not affect the motion in cold-blooded animals, but, of course, a heat considerably higher than this, and such as to alter the tissue, would put an end to it in all cases. Electric shocks, unless they cause abrasion of the ciliated surface (which is sometimes the case), produce no visible effect; and the same is true of galvanic currents. Fresh water, I find, arrests the motion in marine mollusca and in other salt-water animals in which I have tried its effect; but it evidently acts by destroying both the form and substance of the cilia, which in these cases are adapted to a different medium. Most of the common acid and saline solutions, when concentrated, arrest the action of the cilia instantaneously in all animals; but dilution delays this effect, and when carried farther, prevents it altogether; and hence it is, probably, due to a chemical alteration of the tissue. Virchow has observed that a solution of either potash or soda will revive the movement of cilia after it has ceased. Narcotic substances, such as hydrocyanic acid, salts of morphia and strychnia, opium and belladonna, are said by Purkinje and Valentin to have no effect, though the first-named agent has certainly appeared to me to arrest the motion in the river-mussel. Bile stops the action of the cilia, while blood prolongs it in vertebrated animals; but the blood or serum of the vertebrata has quite an opposite effect on the cilia of invertebrate animals, arresting their motion almost instantaneously."

Ciliary motion.

Ciliary motion is a property possessed by the individual cell, and it is still a mystery whence is derived the power by which the cilia act.*

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* Dr Sharpey says:—"Without professing to offer a satisfactory solution of a question beset with so much difficulty, it seems, nevertheless, not unreasonable to consider the ciliary motion as being probably a manifestation of that property on which the more conspicuous motions of animals are known to depend, namely, vital contractility; and this view has at least the advantage of referring the phenomenon to the operation of a vital property already recognised as a source of moving power in the animal body.

"It is true that nothing resembling a muscular apparatus in the ordinary sense of the term, has been discovered to be connected with the cilia, nor is it necessary to suppose the existence of any such; for it must be remembered that vital

Scaly epithelium.

VI. SCALY EPITHELIUM.—The spherical cells of glands are formed on the surface of membranes, whether serous, mucous, or cutaneous, but they become flattened, and either form a single layer, as in the case of the tesselated or pavement epithelium, or are in several layers—stratified—as in the epidermis and so-called cuticular epithelium.

contractility is not limited to a tissue strictly defined in its appreciable structure. The anatomical characters of human voluntary muscle differ widely from those of most involuntary contractile textures, and still more from the contractile tissues of some of the lowest invertebrate animals, although the movements must in all these cases be referred to the same principle. The heart of the embryo beats while yet but a mass of cells, united, to all appearance, by amorphous matter, in which no fibres are seen; yet no one would doubt that its motions depend then on the same property as at a later period, when its structure is fully developed.

"In its persistence after systemic death and in parts separated from the rest of the body, the ciliary motion agrees with the motion of certain muscular structures, as the heart for example; and the agreement extends even to the regular or rhythmic character of the motion in these circumstances. It is true, the one endures much longer than the other; but the difference appears to be one only of degree, for differences of the same kind are known to prevail among muscles themselves. No one, for instance, doubts that the auricle of the heart is muscular, because it beats longer after death than the ventricle; nor, because a frog's heart continues to act a much longer time than a quadruped's, is it inferred that its motion depends on a power of a different nature. And the view here taken of the nature of the ciliary motion derives strength from the consideration that the phenomenon lasts longest in cold-blooded animals, in which vital contractility also is of longest endurance. In the effects of heat and cold, as far as observed, there is also an agreement between the movement of cilia and that of muscular parts. It must be allowed, unless we distrust the observations of every competent inquirer, that narcotic substances do not in general affect the cilia, while they are generally admitted to alter or extinguish muscular action. At the same time there remains some ambiguity on this head, and my own observations do not agree in all points with those referred to. Something, moreover, may depend on the facility or difficulty with which the tissues permit the narcotic fluid to penetrate, which circumstances must needs affect the rapidity and extent of its operation. In the effect of opium on the heart there is a great difference, according as the narcotic is applied to its outer or its inner surface; and to this must be added that the effect of narcotics has not been carefully tried on all contractile tissues. Again, we see differences in the mode in which the cilia themselves are affected by the same agent: thus fresh water instantly arrests their motion in certain cases, while it has no such effect in others.

"The discovery of vibrating cilia on the spores and other parts of certain cryptogamic vegetables may perhaps be deemed a strong argument on the opposite side; but it is by no means proved that the sensible motions of plants (such, at least, as are not purely physical), and those of animals, do not depend on one common vital property."

Tesselated variety.

The tesselated or pavement epithelium is here represented as seen on the inner surface of the pericardium. Admirable specimens are obtained from the ventricles of the brain, as from the pleura, peritoneum, and joints, also from the kidney, and charged with pigment on the choroid coat of the eye. The outlines of the cells are usually very distinct, nuclei prominently seen, and a few granules dispersed around the latter.

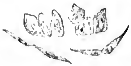
Fig. 12.—Tesselated epithelium from pericardium of sheep. Fusiform cells are shown, such as are constantly seen, especially in young animals.

Scaly epithelium.

Scaly epithelium, properly so called, is very readily demonstrated in specimens obtained from the mouth of any of our domestic animals. Fig. 13 is taken from a specimen of scaly epithelium obtained by gently scraping a horse's mouth. The scales are of various shapes, varying in size from $\frac{1}{400}$th to $\frac{1}{800}$th of an inch. They are frequently seen in solid masses, doubling on each other, and forming a solid, compact layer. Individual cells floating about the field of the microscope are the best for observation. Their outline is very delicate. The granules disappear when acetic acid is added to the fluid in which the scales are immersed, and the cell-wall at last gives way.

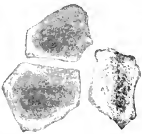
Fig. 13.—Scaly epithelium from horse's mouth.

The cells increase in numbers, and are arranged in solid strata on the conjunctiva (Fig. 14) on the rough tongue of the ox, and indeed on the papillated mucous membrane of this organ in all our domestic animals. In the pharynx, likewise, there is a dense layer of scaly epithelium terminating somewhat abruptly at the openings of the eustachian tubes, and at the glottis. In the œsophagus the mucous membrane is extended by papillary prominences for the abundant production of these cells, so as to obtain a thick and solid layer, which extends in some animals to the cardiac opening, and in others, as in the horse, to the middle of the stomach. In these situations, as indeed on the conjunctiva and elsewhere, many layers of cells accumulate, the deeper, which are more recently formed, approaching the spherical form, and the more superficial being flattened and corneous.

These epithelial cells are capable of undergoing a series of transformations, through which they become extremely unlike what they

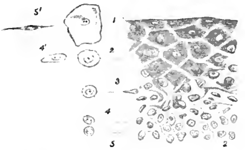

Fig. 14. (Sharpey and Henle.)—Epithelium from the conjunctiva of the calf, folded so that the free surface forms the upper border of the figure, and rendered transparent by acetic acid. 1 2 3 4 5, Progressive flattening of the cells as they rise to the surface. The outline figures represent single cells from different depths, viewed on their surface; and at 4' and 5 edgeways, × 410.

originally were. Virchow refers to this circumstance, and says that the cells "gradually assume appearances which render it impossible for those who are unacquainted with the history of their development to realize their original epidermic nature. The greatest abnormity of the kind is met with in the crystalline lens of the eye, which is originally a mere accumulation of epidermis. It has its origin, as is well known, in a saccular involution of the external skin. At first its connection with the external parts continues to be maintained by means of a delicate membrane, the *membrana capsulo-pupillaris;* afterwards this atrophies and leaves the lens isolated in the interior of the eye. The fibres of the lens are, therefore, as Cloyt has shown, nothing more than epidermoidal cells which have been developed in a peculiar manner, and their regeneration, after the extraction of a cataract, for example, is only possible so long, as there still remains epithelium in the capsule to undertake tho new formation, and to represent, as it were, a thin layer of rete malpighii."

Structure of crystalline lens.

The epidermis which protects the surface of the body, and is an essential element of the skin, is composed, like the stratified layer of epithelium within the body, of superficial layers of hard cells, and of deeper strata of spherical cells, which have been described as forming a rete mucosum or rete malpighii, from the perforations here and there due to the papillæ around which the cells are deposited.

Dr Sharpey says:—"In various parts, the more superficial and denser layers of the scaly epithelium can be readily separated from the deeper, more recently formed, and softer parts which lie underneath, and this has led to the error of describing the latter as a distinct membrane, under the name of rete mucosum."

PIGMENT.

The tissue commonly described under the title *pigment*, is a form of epithelium, or rather composed of epithelial scales coloured by pigmentary granules. We have frequent opportunities of observing large masses of simple pigment granules in melanotic tumours in gray horses. From the irregular deposition of colouring matter in these animals there is a tendency to abnormal accumulations, especially about the tail, lymphatic glands, &c.

Pigment tissue, as shown here, (Fig. 15) is met with in the eye, where it serves to absorb superabundant rays of light—as, indeed, for the same reason that the interior of a telescope and microscope is coloured black. Similar cells, containing pigment, are seen in the skins of dark-coloured animals, or in the negro. In all varieties we have simply pigment granules, impregnating nucleated or epithelial cells.

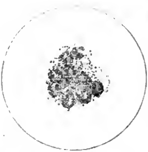
Fig. 15. Pigment from the choroid coat of sheep.

In melanotic deposits in the horse, the pigment granules are not within cells; and the only additional elements we have ever noticed are bright refrangent nuclei, which are rather numerous and always free. We rarely see in the horse melanotic cancer. I have examined only one tumour in which cancer-cells were largely impregnated with pigment, so as to render the growth black. This is not the case in the human subject, in whom, by the term melanosis, a cancerous disease is implied.

With regard to the origin of pigment cells, Virchow says that they are produced in the most different parts by the direct transformation of epidermic cells, the contents of which either become coloured by imbibition, or have pigment engendered in them by a (metabolic) transposition of their elements.

Mr Lister has performed a series of most important observations on the stellate pigment cells of the frog's skin, showing that causes which affected the vital properties of tissue act either as stimuli, or have a paralysing effect on the cells which lead, in the first instance, to aggregation of the pigment granules around the cell nuclei, and, in the second, to their dissemination through the branches of the cells. This occurs without change in the cell-walls, and only from a movement in the molecular pigmentary matter. Mr Lister says that he has seen the granules start off suddenly from the central mass with a velocity which implied that they were under the influence of a vital force, as proved also by the fact, that the function might be paralysed by a galvanic shock or similar agency so as to prevent diffusion as well as concentration.

Pigment granules are chiefly composed of carbon: hence the explanation of this colour, which, as Gmelin has shown, is discharged by chlorine. Scherer[*] states, as the mean result of the analysis of pigment, as follows:—

Carbon . . .	58·084
Hydrogen . . .	5·917
Nitrogen . . .	13·768
Oxygen . . .	22·231
	100·000

Lehmann,[†] who calls this pigment melanin, says that the large quantity of iron it contains indicates that it takes its origin from hæmatin.

HAIR AND WOOL.

As one of the epithelial structures, hair must be noticed here. Every hair has a root or bulb fixed in a follicle in the skin, a stem, and point.

Structure of hair.

It is composed of a softer, medullary portion or pith, and a harder cortical layer. The medulla or pith is traced from near the point to the deepest part of the hair-follicle, where masses of spherical cells are seen to envelop a papilla or vascular projection of the skin, from which, indeed, the hair is formed. The spherical cells, which constitute the root of the hair, may be seen continuous with the cells of the same shape in the epidermis, and which line the hair-follicle so as to form a sheath or *vagina pili* to the hair-bulb. The cells which advance from the thicker portion of the medulla, in the hair-follicle, become dry and flattened so as to form the hard, scaly, cortical portion of the hair; the margin of the latter, when examined by a good microscope, is always found to be imbricated, or, in other words, the cells are superimposed, but their edges are one beyond the other, as in the arrangement of tiles or slates on the roof of a house. It is by friction that, as the cells advance from the root, and become dry and detached, the hair grows thinner and thinner from the loss of cortical scales, and by this simple process the hair tapers to a point. The imbrication of these cells renders wool of great value for the manufacture of various fabrics. It is to the projecting serrated margins of the cells that fine waved transverse lines on the surface of the hair are due, and which are seen by the microscope.

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[*] *Ann. de Chimie, u. Pharm.* Vol. xl., page 6.

[†] *Physiological Chemistry.* By Professor C. G. Lehmann; translated by Dr Day. Printed for the Cavendish Society, 1850.

Imbricated scales.

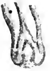


Fig. 16. (Reissner.)—A hair papilla, showing its relations with the hair bulb and lining of the hair follicle.

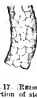


Fig. 17. (Reissner.)—Portion of stem of wool from the sheep, showing the imbricated scales of the cortical substance.

The cells immediately beneath the imbricated scales are fusiform and flattened, so as to give rise to the fibrous appearance.

Colour of hair.

The colour of hair is due to pigment granules diffused between the cells, and which are sometimes confounded with little air-cavities, best seen in white hairs, and between the longitudinal fibres of the cortical substance.

It is a remarkable fact, that "notwithstanding the closest search, Laër was unable to discover any special pigment in the hair, although the microscopical examination of the cortical substance of differently coloured hairs,—that is to say, the existence of certain coloured molecules,—indicates the presence of a definite pigment. It is, however, well known that white hair is especially rich in air, and that to this circumstance it mainly owes its glistening colour. Laër has further shown, by numerous experiments on differently coloured hair, that the iron which is present, and to which Vanquelin had drawn attention, exerts no influence whatever on its colour."—(Lehmann.)

The medulla or pith before-mentioned is in some thin hairs entirely absent, or the spherical cells are scanty, and pressed into various shapes.

Development of hair. At the spot where a hair is to develop, a thickening is noticed. Here the epithelial cells accumulate in large numbers, and press on the hypertrophied portion of vascular skin which is to be the papilla. By the progressive accumulation of the cells, a deep recess is formed, which becomes the hair-follicle. From the vascular papilla, by this time fully formed, material is thrown out by which the cells are enabled to multiply, and, being pressed up in the follicle, find their way at last through the superficial layer of cuticle beneath which cells first began to accumulate. Thus the hair breaks its way through the solid epidermis, and is, as Virchow would express himself, the result of the *proliferation* of the deeper cells; or, in Dr Beale's phrascology, may be described as 'formed material' advancing, and in different stages of change, from the 'germinal matter' near the vascular papilla, to the corneous cortical layer and point.

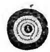


Fig. 18. (REISSNER.)—Transverse section of a developing hair in its follicle; *e*, Outer sheath of the hair; *f*. Inner sheath; *h*, Stem of the hair.

HORN.

The horns, claws, nails, and hoofs of animals are all composed of material similar to hair, and are often spoken of as built up of hairs firmly matted together. The same cell which forms the scaly epithelium, epidermis, and hair, is utilized in building up the horny structures. The special history of the horny appendages of animals consists, therefore, in the description of the form and disposition of the surfaces from which they spring.

Papillated structures. Whereas hairs have a root imbeded in a follicle, horn springs from papillæ, which stud a surface extended over a bony or fibro-elastic prominence. Thus the papillated tissue, whence spring the horns of cattle, sheep, &c., forms a covering to the processes of the frontal bones, which are pierced by large foramina for the transit of blood-vessels.

Foot of horse. In the foot of the horse we observe the skin, at the part where hair and horn meet, thickened—coronary band—and towards the posterior part of the foot the subcutaneous tissues are transformed into that vast fibro-cartilaginous cushion, constituting the elastic basis over which the resilient horn of the frog is formed. From the coronary band downward, permanent folds, laminæ, or podophylla (Clark), are arranged in parallel lines. They are from 550 to 600 in number, and like the papillæ, destined for secretion of the agglutinating cells, which form the matrix of horn. As Virchow mentions with regard to the human nail, each lamina corresponds to the single papilla seen on the surface of the skin. The cutaneous surface beneath the os pedis, over the fibro-elastic frog and the lateral cartilages, forms, with the coronary band, an extensive bed of papillæ.

The surface of the horn has a fibrous appearance, and the fibres run in a parallel direction and in a straight line from the papillæ which form them. Thus the papillæ on the coronary band, frog, and vascular sole, are all directed downwards and forwards.

Different consistence of horn.

If a hoof is cut perpendicularly, it is found that the deeper layers are soft, and the tissue becomes progressively harder from within outwards, so that the surface is firm and dry. The difference between the deeper and more superficial parts depends to a great extent on the influence of aërial contact affecting the latter.

The so-called horny fibres are funnel-shaped at the point of connection with their respective papillæ. Each fibre has a medulla or pith, composed of soft spherical or polyhedral cells, and of a cortical portion, which has a fibrous appearance, due to elongated fusiform cells, like the cortical portion of the hair. The thickness of the fibres varies; those at the surface of the wall of a horse's hoof are the smallest and most compact. Between these fibres there is an intermediate substance, best seen on examining a transverse section of horn. Such a section (Fig. 20), when examined by transmitted light, affords us a view of the concentric layers of horn-cells surrounding the soft opaque medulla, besides the connecting substance formed by a dense mass of cells similar to those which constitute the fibres, but disposed in an opposite sense, lying flat on each other at right angles with the fibres. This dense bed of cells forms the bond of union between the fibres, which become loose and detached from each

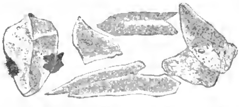


Fig. 19.—CHAUVEAU.—Different forms of horny scales. The cell to the left is one from the softer and deeper layers, and is charged with two pigment masses, × 300.

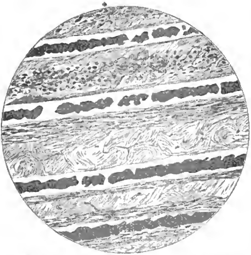


Fig. 20.—(Chauveau.)—Longitudinal section of four horn fibres of the wall, taken from the point of union between the white and dark horn. The dark material in the centre of the fibres is composed of opaque spherical cells, which appear dark when seen by transmitted light.

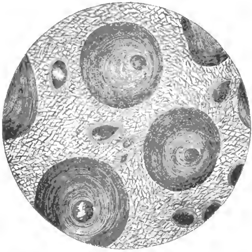


Fig. 21.—(Chauveau.)—Transverse section of several horn fibres of the horse's sole, shewing the concentric arrangement of scales around a central medulla; also the superimposed cells constituting the agglutinating material, × 100.

other where the horn gets dry, and the intermediate substance crumbles out.

The fibres, we have said, are formed from the papillæ, but the cells of the material which joins them are produced from the surface between the papillæ and the deeper layers from the surface of the laminæ or podophylla. Thus the horn fibres descend over the laminæ, and are attached to these by cells constantly developed, and which act as the agglutinating material.

Pigment of horn.

The pigment which colours all dark horn is disposed irregularly between the cells of the fibres, as in the case of hair, and has no very regular disposition.

Difference in horn of wall and sole.

The difference between the horn of different parts of the horse's hoof depends not a little on the relative amount of fibres and interfibrous substance. The horn of the wall is tough, and breaks up into fibres as it grows beyond a natural length. This is due to the toughness acquired by the fibres in their lengthy course, and to the crumbling of the cells between them as mentioned above. The horn of the sole is detached in flakes, and this depends on the fact that the fibres are short, do not pass over or into a bed of agglutinating material, and when at a certain distance from the papillæ whence they originate, they break off. Flakes are thus detached from the frog. The growth of horn is unlimited, and in the case of the horse's hoof, we find that if, from the feet being protected by an iron shoe, and injudiciously managed, certain parts are allowed to grow beyond the natural depth which would occur if the animal were free and in a state of nature, they imprison other parts between them, and lead to the accumulation of masses of firm and unyielding horn, which inflict injury. The unlimited growth of the fibres is beautifully illustrated by the annexed engravings, and which represent the hoof of a mare grown to an enormous depth, and peculiarly curved, from the bearing having taken place on the side of the hoof. (Figs. 23, 24, page 48.)

Unlimited growth of horn.

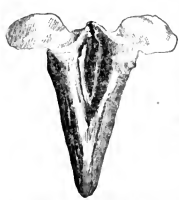


Fig. 22. Frog of the horse, showing the separation of flakes.

The mare had been turned out after fracture of the long pastern bone; and, from the deformity which resulted, the foot could not be brought firmly to the ground, and was therefore not worn away.

Growth of human nail and horn of animals similar.

The growth of the wall of a horse's hoof is in every respect similar to the growth of a human nail. I shall quote from Virchow:—"If we consider the nail with respect to its proper firm substance, its compact *body* (Nagelblatt), this only grows from behind, and is pushed forward over the surface of the so-called *bed of the nail* (Nagelbett), but this in its turn also produces a definite quantity of cellular elements, which are to be regarded as the equivalents of an epidermic layer. On making a section through the middle of a nail, we come, most externally, to the layer of nail which has grown from behind, next to the substance which has been secreted by the bed of the nail, then to the rete malpighii, and lastly to the ridges upon which the nail rests.

"Thus the nail lies in a certain measure loose, and can easily move forwards, pushing itself over a moveable substratum, whilst it is kept in place by the ridges with which its bed is beset. When a section is made transversely through a nail, we see, as already mentioned, essentially the same appearance presented as that offered by the skin, only that a long ridge corresponds to every single papilla seen in ordinary sections of the skin; the undermost part of the nail has slight indentations corresponding to these ridges, so that, while gliding along over them, it can execute lateral movements only within certain limits. In this manner, the body of the nail which grows from behind moves forward over a *cushion* of loose epidermic substance in grooves which are provided by the ridges and furrows of the nail. The uppermost part of the nail, if examined when fresh, is composed of so dense a substance that it is scarcely possible to distinguish individual cells in it without applying reagents, and at many points an appearance is presented like that which we see in cartilage. But by treating it with potash, we can convince ourselves that this substance is composed of nothing but epidermis-cells."

Explanation of morbid states.

As Virchow justly observes:—"From this mode of development, an easily intelligible distinction may be drawn between the different diseases of the nails," and we might add, of the horse's hoof. The causes of false quarter and seedy-toe, the appearances of canker, and the changes which occur in the hoof in cases of laminitis, are most satisfactorily explained. There is only one of these affording a useful illustration of the manner in which horn is formed that we shall rest upon. It is the deformity resulting from laminitis,—knollhuf of

Fig. 23.

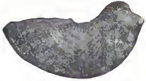


Fig. 24.

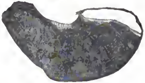


Fig. 26.

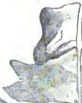
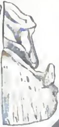


Fig. 27.



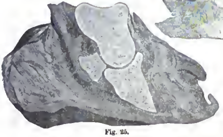


Fig. 25.

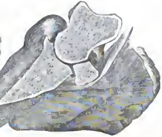


Fig. 28.

Figs. 23, 24. Two side views of a mare's hoof which had grown to an extreme length. The mare having sustained a fracture of the long pastern, could not bring her foot fairly to the ground, and consequently the hoof was not worn.

Fig. 25. Deformity in the hoof from excessive growth of the cellular horny matrix on the surface of the laminæ, whereby the front of the os pedis has been pressed upon to produce the alteration shown by Fig. 26, besides deformity of the wall of the hoof.

Fig. 26. Front view of one-half os pedis atrophied, as the result of changes within the hoof from laminitis.

Fig. 27. Front view of one-half healthy os pedis.

Fig. 28. The natural position of the os pedis in relation to the healthy hoof.

the Germans,—in which a great enlargement occurs at the toe, believed generally to be due to a descent of the os pedis. The change is gradual. From inflammatory action, a separation occurs between the podophylla (vascular laminæ), and keraphylla (horny laminæ.) As the inflammation subsides, the space, however small, becomes filled up by the cells which usually agglutinate the horny fibres; but as these are detached, they only become more and more elevated, and the space between the horny wall and the os pedis increases. The toe of the latter becomes atrophied, and it is impossible to obtain a restoration of the wall, because the fibres are pushed outwards by the enormous mass of cells found beneath them.

Onychogryphosis.

There is a disease of the human nail (Onychogryphosis), in every way similar to the above-mentioned deformity of the horse's hoof. Virchow refers to it as follows:—"When there is a very abundant development of cells in the bed of the nail, the body may be pushed upwards, nay, it sometimes happens that the nail, instead of growing horizontally, shoots perpendicularly upwards, the space underneath being filled with a thick accumulation of the loose cushiony substance."

CONNECTIVE TISSUE.

Connective tissue.

There is a structure more abundant than all others in the animal body, and which is adapted in the form of protecting and secreting layers, such as the skin, mucous and serous membranes; it constitutes a mesh for the connection of parts with each other, such as between the skin and tissues beneath it; it surrounds muscles, in the form of a tough, inelastic sheath (fascia.) It attaches the muscles to bone, through the substance of which it is continuous, and penetrates the substance of organs. It sometimes contains much elastic material, and its elements are peculiarly adapted in forming solid but pliant tubes, or rebounding cushions within joints. Professor Kölliker* has very happily expressed the general characters of connective substance. He says:—"The tissues belonging to this group, viz., mucous tissue, cartilage, elastic and non-elastic tissues, as also the tissue of the bones and teeth, present, both in a histological and chemical point of view, such manifold differences, that it is, properly speaking, only the *genetical connection between them* and *their correspondence in function*, which keeps them together. In the latter respect, connective substance serves as a support and investment for all the other parts of the body, and might even be designated, with a still more general expression, viz., 'substance of support,' or 'sustentative substance.' As such, it forms, firstly, the solid framework of the whole body (cartilages, bones, and ligaments of the internal skeleton; the external skeleton—except the horny structures—free cartilages and bones of internal parts); secondly, the investment of groups of organs, single organs or parts of organs (corium, mucous membranes, fibrous membranes, sheaths of muscles, nerves and glands, vessels); thirdly, and lastly, a packing or connecting material between individual organs and parts of organs (adipose tissue, medulla of bone, loose areolar tissue, vitreous humour, tendons.) Kölliker, moreover, alludes to a genetical connection between the above-mentioned tissues being formed from a similar material, and convertible one into another. Dr Martyn, in referring to this subject in an able paper published in the *Archives of Medicine* (No. 6, 1859, page 108), says that there is "a true morphological relation between these tissues, for they all consist of cells more or less branched in character, and having a substance outside them. . . . . Chemically too, all these substances are allied in yielding either gelatine, or what is very similar, chondrine. Although it is to the genius of Reichert that we owe the theory of the connective group, it must not be supposed that the scheme was laid down at once in its present extensive application. Reichert's paper had remained for five years without other notice than contradiction, when an important move was made by certain demonstrations of Virchow, Kölliker, and Sharpey, who showed that, pathologically and normally, bone is developed from connective tissue; and that the latter, when about to ossify, often assumes the character of cartilage. Almost at the same time (1851-52), Donders, Henle, Remak, and others, described the 'nucleus fibres,' their attachment to cell or nuclei, and their possible development into elastic tissue."

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* *A Manual of Human Microscopic Anatomy.* London, 1860.

Dr Beale does not admit the production of these nucleus fibres, and one of the assumptions on which the connective-tissue doctrine is based. Virchow, says Dr Beale, *assumes* the possible existence of *tubes* in the yellow elastic fibres, which are as *solid* as anything can be. The nucleus fibres are prolonged in *straight lines*, but are not and never become yellow elastic tissue.

Virchow enters fully into the discussion regarding the nature of connective-tissue, and regards it as developed from cells which persist

Nature of connective tissue.

in any form the structure may assume. These cells are spindle-shaped and stellate (Fig. 29); and Virchow agrees with Reichert, that a direct splitting up of these cells, as believed by Schwann, does not take place. The following diagram indicates Virchow's views of the development of connective-tissue. (Fig. 30.)

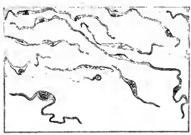

Fig. 29.—(Virchow.)—Connective tissue from the embryo of a pig, after long-continued boiling. Large spindle-shaped cells, connective-tissue corpuscles (Bindegewebs-körperchen), some isolated, some still imbedded in the basis-substance, and anastomosing one with the other. Large nuclei with their membrane detached; cell-contents in some cases shrunken, × 350.

Dr Beale's views.

Dr Beale's researches on the connective tissues have led him to form a view totally different from those we have just given. He states that the 'intercellular substance' of cartilage, white fibrous tissue, &c., exactly correspond with the so-called cell-wall, and part of the contents of an epithelial cell, and he holds that both cell-wall and intercellular substance were once in the state of germinal matter. So far from considering that the intercellular substance is produced independently of the cells or nuclei, he affirms that there is no instance in which this material is produced without the so-called cells or nuclei being present, and he tries to prove that cartilage and tendon grow in precisely the same manner as epithelial structures. In the latter the formed material in that part which is oldest gives way, so that each mass of germinal matter is surrounded with a portion distinct and separated from its neighbours, while in the latter structures their separation does not take place, and the formed material, through the whole tissue, is continuous. Dr Beale maintains that the matter of which the so-called 'nuclei' or cells, in cartilage, tendon, &c., becomes

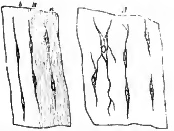

Fig. 30.—(Virchow.)—Diagram of the development of connective tissue. *A*, Earliest stage. Hyaline basis-(intercellular) substance, with largish cells (connective-tissue corpuscles; the latter drawn up in rows at regular intervals; at first separated, spindle-shaped, and simple: at a later period anastomosing and branched. *B*, More advanced stage: at *a*, the basis-substance which has become striated (fibrillated), presents a fasciculated appearance on account of the cells imbedded in it in rows, the cells becoming narrower and smaller; at *b*, the striation of the basis-substance has disappeared under the influence of acetic acid, and the fine and long anastomosing fibre-cells (connective-tissue corpuscles), still retaining their nuclei, are seen.

the 'intercellular substance' just as the matter of the 'nuclei' of the epithelial cell gradually becomes converted into the matter of which the 'cell-wall' is composed. He also holds most positively that the nuclei of tendon represented in Fig. 32 produce or are converted into the striated white fibrous tissue, and that they have nothing whatever to do with the formation of the delicate fibres of yellow elastic tissue met with in small numbers in connection with this tissue. Compare Dr Beale's figure with Virchow's diagram. If these views of Dr Beale's should be established, the structure of the connective tissues is really very much more simple than is generally believed, and these connective tissues are produced according to the same laws which govern the epithelial and other tissues.

AREOLAR TISSUE.

Areolar tissue.

This is the true connective tissue of the body, fulfilling the office of a connecting medium between different parts and organs. It is a white, silvery, mesh-like substance, lubricated by a fluid which it secretes, and distended also by fat-cells, which vary in amount under different circumstances. One remarkable feature observed with regard to this tisssue is, that its meshes or areolæ communicate with each other, and are not limited spaces. When a butcher wishes to give a bloated appearance to a sheep, he makes a small incision into the flank, or other part where the areolar tissue is abundant, and blows into it, thus distending the same structure all over the body. Again, we find that, in the event of any dropsical effusion occurring, the fluid descends to the most dependent areolæ, at the lower part of the limbs, chest, and belly.

Areolar tissue is not limited by any well-defined boundaries. It passes into, and indeed forms the true skin; it dips into the muscles, penetrates organs, and is, in fact, freely distributed wherever we wish to examine the connection of parts.

Microscopical characters.—When a very small quantity of areolar tissue is teased, and placed under the microscope, it is found to be composed of bundles of extremely delicate filaments (from $\frac{1}{1000}$th to $\frac{1}{25000}$th of an inch in thickness), taking a waved course in opposite directions, and leaving spaces between them. Coiled fibres of some thickness, with well-defined margins, and cut sharply across, being peculiarly curled at their broken ends, are the elastic fibres, which are interspersed between the bundles of much more delicate filaments above described. Nuclei, or oval masses of granular matter, (Dr Beale's germinal matter), are seen interspersed on the bundles of white filaments, and these become readily tinged with carmine.

If acetic acid be added to the areolar tissue, the white bundles swell, lose their fibrous character, and assume an irregularly swollen appearance, due to the elastic fibres coiled around them, and constricting the mass which they encircle.

Different forms of the areolar tissue.

Different forms of areolar tissue have been described, and there are varieties in accordance with its origin in special parts, though sometimes appearances are deceptive, and what is taken to be areolar tissue is really some other structure, as shown by Dr Beale. Of the forms of this structure, he says that there are:—

"1. Certain forms both of white and yellow fibrous tissue which are produced directly from germinal matter as other tissues, and in which masses of germinal matter may be demonstrated at every period of life.

"2. Certain forms which may be regarded as the residue of higher tissues which have ceased to discharge active functions.

"3. Certain forms of fibrous tissue (indefinite connective tissue), as in the papillæ of touch and taste, which result from changes having occurred in the terminal branches of the nerve-fibres.

"4. Certain forms of fibrous tissue, resulting from degeneration occurring in the course of disease.

"5. An appearance of fibrous tissue produced by pressure, crumpling, and stretching of nervous capillaries and other tissues."

Areolar tissue is supplied with blood by a scanty mesh-work of capillaries, emerging from vessels which pass through this substance between parts which it connects. It may be divided without inflicting pain, though at intervals a sudden cry or struggle may be perceived in operating on animals, and which is due to the division of some nerve-trunk, passing through the connective texture. Absorption goes on rapidly when fluids are injected into the areolar tissue.

Areolar tissue is composed of gelatine, and contains a large amount of water.

WHITE FIBROUS TISSUE.

White fibrous tissue.

The tough white fasciæ, the inelastic silvery ligaments and tendons, are composed of bundles of white filaments similar in every respect to the bundles of areolar tissue. They are all, however, arranged in a parallel manner, binding firmly together structures with which they are continuous at their ends. Interspersed amongst the bundles of filaments are elongated fusiform nuclei, or, as Dr Beale calls them, "oval masses of germinal matter." The fibrous substance is therefore Dr Beale's 'formed material.'

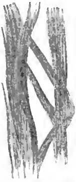

Fig. 31. Fibrous tissue for sheep's leg.

The nature of the nuclear fibres.

However tough and apparently inelastic this texture is, it contains, nevertheless, some yellow elastic fibres. These have been called *nuclear fibres* by some histologists. Regarding the nature of the nuclei and nucleated fibres, Dr Beale says:—"If the tendon be stretched they form narrow lines, and the very elongated nuclei seem to be connected together by very delicate fibres. If the specimen be roughly handled, several nuclei may be detached, and they often assume an angular form with several projecting processes. If, on the other hand, they be stretched laterally, they become very wide and assume an oval form. Longitudinal lines are seen in the oval masses, and these are caused by a tendency on the germinal matter to split in the longitudinal direction, or result from peculiar creasings or markings, which, when fully formed, give rise to the fibrous appearance so characteristic of this tissue. If you attempt to make a transverse section, you obtain the stellate bodies to which I have referred. It is impossible to obtain a very thin transverse section of tendon with these nuclei in their natural position. In attempting to do so, you cut off that piece of tendon with the included nuclei. At the edge of the specimen are some bands of wavy fibres detached, with the nuclei in them, and in some the immediate continuity of the fibrous structure can be positively traced."

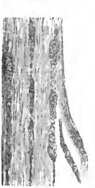

Fig. 32.—(BEALE.)—Actual copy of the tissue of a tendon of a kitten at birth, 700 diameters. The nuclei represented on the right of the drawing are shown to be continuous with the white fibrous tissue, and not with yellow elastic fibres, as Virchow believes.

With regard to the connection between the nuclei and the yellow elastic material, Dr Beale says:—"In many specimens of young tendon it is difficult to demonstrate a single fibre of undoubted yellow elastic tissue. The yellow elastic fibres are always less numerous in young than in adult tendon, while the so-called nuclear fibres are two or three times more numerous in the former than in the latter. The proportion of yellow elastic tissue, therefore, does not seem to be dependent upon the so-called nuclei. The yellow fibres, where they exist, are not connected with the nuclei, and are often separated from them by white fibrous tissue."

Structure of fasciæ.

The arrangement of the white fibre in fasciæ is similar to the disposition in tendons. Strips of parallel bundles interlace each other, and there is a quantity of reticular connective tissue uniting these together.

It is the toughness and inextensibility of white fibrous tissue that render it so serviceable in attaching muscle to bone, or uniting bones where they articulate with each other. The tissue is but slightly vascular, and contains fewer blood-vessels in the adult than in the young animal. The division of tendons, fasciæ, and ligaments is unattended with pain, so that these structures are devoid of sensibility.

Reproduction of white fibrous tissue.

There is no tissue more readily reproduced, and the only condition for effectual re-union is, that the divided ends be brought as close together as possible, in order to prevent any increase in the length of the bond of union. The perfect rest of parts is the best means to ensure the healing of a cut or torn ligament or tendon. No other means can be adopted so as to increase the strength of the white fibrous tissue, and we mention this very particularly here because veterinarians still resort to blistering and firing, in the belief that they ensure animals from not lacerating tendons or ligaments a second time.

ELASTIC TISSUE.

Elastic tissue.

This structure, which is of a yellow colour, when accumulated in quantities in the form of fasciæ or ligaments, is seen in very considerable quantities in the lower animals, and especially in the horse. It forms the ligamentum nuchæ, which tends to suspend the head from the spinous processes of the dorsal vertebræ. It is seen in the pregnant mare or cow, forming a very thick fascia over the abdominal muscles. It enters largely in the formation of the elastic structure of the foot of the horse, and is moreover met with as the ligamenta subflava between the arches of contiguous vertebræ, in the larynx, trachea, pharynx, œsophagus, blood-vessels, skin, &c.

If a specimen be chosen from the ligamentum nuchæ or ligamenta subflava, it will be found composed of fibres, varying in size from $\frac{1}{1500}$th to $\frac{1}{8000}$th of an inch in diameter. They are clear, transparent, with a well-defined outline, truncated, and sharply recurved ends. They inosculate, and in some parts the anastomoses are so close together as to give the appearance of a membrane, pierced by apertures of various sizes. In some instances the perforations are so regular as to give the fibres a beautiful striped appearance. It is in the arteries that Henle's fenestrated membrane is seen, and which consists in a densely interwoven net-work of elastic fibres, so as to give the appearance of a perforated homogeneous membrane.

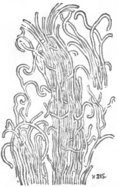

Fig. 33. — (Beale.) — Yellow fibrous tissue, the fibres of which have been unravelled; from the ligamentum nuchæ of a sheep.

With regard to the chemical characters of elastic tissue, Lehmann says:—"The chemical investigations of elastic tissue which have been hitherto made, have unfortunately not led us to any clear knowledge of its constitution and general chemical relations. J. Müller and Eulenberg obtained, by the prolonged boiling of elastic tissues, a non-gelatinizing fluid, which yielded some reactions similar to those afforded by long-boiled chondrin. Mülder and Donders failed, on the other hand, in obtaining any gelatinous substance after forty hours boiling, from well-purified elastic tissue, which had been freed from all admixture of connective tissue and fibre-cells, by means of acetic acid and a solution

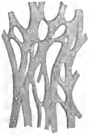

Fig. 34. (Kölliker.)—Elastic network from the *tunica media* of the pulmonary artery of the horse, with holes in the fibres. Magnified 350 times.

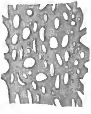

Fig. 35. (Kölliker.)—Elastic membrane from tunica media of the carotid of the horse. Magnified 350 times.

of potash; and they also found, on making a microscopical examination, that the fibres were entirely unchanged."

This tissue, so valuable for its great elasticity, and even strength, is but slightly vascular when accumulated in the form of fasciæ, &c., and is not endowed with sensibility. We have repeatedly cut portions of the ligamentum nuchæ of the horse, and never saw any indication of pain from the section.

MUCOUS TISSUE.

Mucous tissue.

The umbilical cord must be classified with those tissues which, though transmitting blood-vessels, are not supplied by any. Professor Virchow has shown that capillaries only extend about four or five lines from the abdominal attachment of the cord, and that it is only this portion which remains after birth. On making a transverse section of the umbilical cord, the arteries, with their very muscular coats, are seen surrounded by a gelatinous substance, which formerly went by the name of jelly, and which Virchow describes as a tissue of typical form. He ranks it with subcutaneous tissue, and describes it as formed by a fibrous net-work, in which lie numerous stellate anastomosing corpuscles; to these corpuscles Virchow attributes the important function of effecting a uniform distribution of the nutritive juices.

We subjoin an engraving of the fibrous net-work before alluded to, and which Dr Beale describes as enclosing delicate fibres without regularity, the interspaces between which being occupied with a transparent fluid. Dr Beale is probably correct in stating that there is not a special system of nutrient canals in this tissue, as suggested by

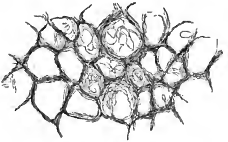

Fig. 36. Reticulated tissue of umbilical cord, × 500.

Virchow, and that it is a soft form of fibrous tissue, produced in the same manner as the formed material of other tissues.

After describing this structure, Kölliker states that "in normal histology there seems, for the present, no reason for assigning a place to a form of tissue of the composition of gelatinoid connective tissue, since such a one never occurs in the fully-developed body." He adds that he has accordingly only reckoned the vitreous body under the present head in the meantime.

Scherer has found that this tissue contains no gelatine, but consists, in addition to fusiform cells, of a peculiar intercellular substance, which, on digestion with water, yields not only albumen, but a gelatinous or mucous substance.*

ADIPOSE TISSUE.

Fats.

Fatty tissue.

Fatty matter is abundant in the bodies of animals, and may be found in two forms: Firstly, The fats that are saponifiable; Secondly, Those that are non-sponifiable. The first are met with chiefly enclosed in membranous vesicles in different parts of the body, filling up the areolæ of connective tissue. This is the adipose or fatty tissue we are about to describe. The second are usually met with in a crystalline form, either in secretions or in the interstices of tissue.

Microscopical characters.

If a small portion of fatty tissue from any animal is placed under the microscope, using a lens that will magnify from 150 to 300 diameters, bright refrangent vesicles are observed, the outlines of some being seen through the more superficial cells, and all being somewhat flattened at their points of contact. The irregularity in the shape of these vesicles may be seen in the annexed sketch of fat from a sheep's foot. Around the cluster of fat-cells, globules of oleine are floating, and these vary largely in size, and move freely in the field when anything tends to disturb the plates of glass between which the object is secured.

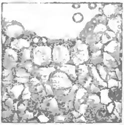

Fig. 37. Adipose tissue from sheep's foot.

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* Professor LEHMANN'S *Physiological Chemistry.*

Google

The fat vesicles are composed of a homogeneous membrane, which in very young animals is seen to have a nucleus connected with it. This parietal nucleus is shown in the annexed figure in the fat-vesicles of the newt.

The fat-vesicles are connected by fibres of areolar tissue, and are indeed imbedded in connective tissue. They are supplied with capillaries which ramify on their surface, and through which the fatty material is deposited.

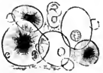

Fig. 38.—(BEALE.)—Adipose tissue from the abdominal cavity of a newt, near the situation of the ovary. The nuclei of many of the fat-vesicles are unusually distinct, × 215.

Where fatty tissue exists.

Fatty tissue is found in and beneath the skin—*panniculus adiposus*—within the medullary canal of bones constituting the marrow; and behind the eye-ball supporting the latter in a prominent position within the orbit. It varies largely in amount around the heart, kidneys, and in the omentum. It is seen in the mesentery, where in fat animals it constitutes the appendices epiploicæ, occasionally hypertrophied, so as to constitute pedunculated fatty growths in the horse.* The cushion of elastic tissue within the hoofs of animals contains some adipose tissue, and within the joints the Haversian fringes, formerly supposed to be glands, are deposits of fat within folds of the synovial membrane. There are certain structures in and around the globe of the eye in which fatty tissue is never met with, such as the brain, the lungs, erectile organs, eyelids, &c.

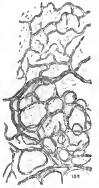

Fig. 39. (BEALE.)—Adipose tissue, with vessels injected, from the capsules of the kidney of the dog, × 130.

Fatty tissue in emaciated animals.

When animals are emaciated, the fat-vesicles become distended by serum, as may be seen around the heart and kidneys of old and very lean horses. In dropsical animals the fat-cells become distended with a watery serum. Sometimes crystals are seen in the fat-cells, which may be due to changes after the separation of fatty tissue from the body, as Dr Roscher of Norway says that the crystallization frequently occurs in drying fat-cells.

Fatty tissue in obesity.

When animals lay on fat in excess, it would appear that not only are the existing vesicles of adipose tissue extraordinarily distended, but additional vesicles are produced, and any portion of connective tissue may be rendered a reservoir for fat. Thus, within the substance of muscles, and even occupying the position of the fibrils, oil-globules in abundance are found. The fat accumulates at the expense of other tissues, and these, having their nutrition impaired, and being thrown into inactivity in animals in a state of obesity, lose their aptitude for special functions, and a positive paralysis is the result. It is such a paralysis of function that we notice in the fat cow which does not breed, and in the bull rendered impotent by over-feeding.

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* See *Our Domestic Animals*, Organs of Digestion, page 278.

Uses of fat.

Adipose tissue is a bad conductor of heat, and thus retains it within the body. The fats are hydro-carbons, burned for the production of animal heat, and are sufficient to support life for a time when food is not taken. This is well exemplified in hybernating animals. Fatty tissue contributes to the preservation of animal form, and in some parts it acts mechanically as a supporting or packing material.

CARTILAGE.

Different forms.

Simple cartilage. Fibro-cartilage.

Spongy cartilage.

This is a firm, elastic material, well known by the name *gristle*, and varying in properties and constitution in different parts of the body. There are four distinct forms, all composed of cells lodged in cavities or spaces within a matrix or intercellular substance. 1. The matrix is clear, translucent, and breaks with a choncoidal fracture in simple or hyaline cartilage. 2. It contains bundles of white fibres, rendering it tough in fibro-cartilage. 3. Elastic tissue is mingled with the intercellular substance in spongy or reticulated cartilage. 4. Cartilage tissue may be composed of cells without any basal substance, as in the chorda dorsalis of the embryo.

Microscopical characters.

If a slender slice of cartilage from a joint is placed under the microscope, it is found composed of cells dispersed in a translucent substance which reflects the light in a peculiar manner. Each cell has a nucleus and granular contents. It is oval or round, and usually flattened. One or more cells are enveloped by a capsule or external secondary membrane, which is continuous, or with difficulty separated from the clear translucent matrix. Embryonic cartilage is a mass of cells, without or with only a very slight amount of intercellular substance. Kölliker has insisted on the fact that the lacunæ or spaces within the cartilage matrix have distinct walls, within which are enclosed the cells which, according to Virchow, are perfectly formed, and with delicate envelopes. The simple or hyaline cartilage is found in joints, in the alæ nasi and cartilages of prolongation to the ribs, as in the larynx, such as the thyroid, cricoid, and arytenoid cartilages.

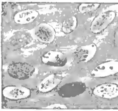

Fig. 40.

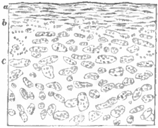

Fig. 41.

Fig. 40. Cartilage from fetlock-joint of sheep.

Fig. 41.—VIRCHOW.—Perpendicular section through the growing cartilage of a patella. *a*, The articular surface, with spindle-shaped cells, (cartilage corpuscles), disposed in layers parallel to it; *b*, Incipient proliferation of the cells; *c*, Advanced proliferation, large roundish groups, within the enlarged corpuscles, a continually increasing number of round cells, × 50.

Fibro-cartilage. Fibro-cartilage consists of the same cartilage cells within a matrix, consisting of large bundles of white fibres interwoven and continuous with connective tissue. It is found in the windpipe, on the summit of the scapula, on the sternum, in the ear, eustachian tubes, intervertebral substance, &c.

Yellow cartilage. With regard to the yellow or reticulated cartilage, Kölliker says: "The epiglottis, the cartilages of Santorini and Wrisberg, and also, according to Rheiner, the processus vocales and apex of the arytenoid cartilage, consist of yellow or reticulated cartilage. This presents: 1. Dark fibres, very densely interwoven, which are much thicker in some animals than in man (in the ox, for example). 2. Large translucent cartilage capsules, 0·01‴ to 0·02‴ in diameter. In one of these capsules Henle has observed a concentric disposition of such a nature that the remains of the cell-cavity resembled a simple bone-lacuna, with a few processes from it.

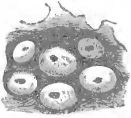

Fig. 42. Yellow cartilage from the epiglottis of a lamb.

On the nutrition and development of cartilage, Kölliker says: "In growing cartilages, the nutritive change is very energetic, and in certain places they always contain numerous blood-vessels, in special canals, and, as I have shown in the septum nasi of the calf, even nerves. The cartilages are developed from the primitive embryonal cell masses; the cells of the latter becoming converted into cartilage cells, and, at least in many cases, a homogeneous intercellular substance appearing between them, which is derived from transuded constituents of the blood. The growth of cartilage is affected, firstly, by endogenous cell-multiplication, traces of which are always discernible even in fully formed cartilage; and, secondly, by the deposition of an intermediate substance from the blood-plasma between the cells, which, in every case, at first solely constitute the cartilage. . . . . In fully developed cartilage, the change of material is certainly not energetic; and apart from the vessels of the perichondrium covering many cartilages and those of the adjoining bone, no special means are provided for effecting such change, except in the cartilages of some mammals."

Dr Beale on nutrition of cartilage.

According to Dr Beale's view of the nature of tissues, the cells of cartilages are composed of the germinal matter, and the matrix is the formed material. He says: "At an early period of development of all forms of cartilage, masses of germinal matter are seen situated very close to each other, and as the growth advances, the quantity of formed material between them (matrix, intercellular substance) gradually increases. It is formed from the germinal matter. If you examine any of those cartilages, in which small parcels of cells exist, at intervals through the matrix, you will observe that there exists a greater amount of formed material between the various collections, than between any of the individual masses of each collection. If it be admitted that the matrix is formed from the masses of germinal matter, this fact is at once explained. The more recent the divisions of the germinal matter the thinner will be the intervening layer of formed material between the resulting masses."

The nutrition of cartilage is explained, therefore, by these cells imbibing and assimilating material which is progressively added to the matrix.

Changes of cartilage with age.

With age cartilage, especially in joints, is invaded by neighbouring tissues. Calcareons particles become disseminated through its matrix, and in some instances fibrous tissue. Whenever cartilage is fractured, the union occurs by connective tissue. Whenever joints ulcerate so as to remove a considerable portion of the cartilage, restoration to health only occurs to the extent of fibrous adhesion, a we see between the flexor pedis and the navicular bone in ulcerative disease of the latter. Cartilage is therefore not reproduced, though it is not unfrequently met with as a constituent of morbid products.*

Uses of cartilage.

The pliancy and rebounding properties of cartilage render it of great service as a protecting structure, and in supporting parts, or affording attachment to muscles, &c.

OSSEOUS TISSUE.

Lacunæ.

The essential element of bone is the lacuna, a microscopic cavity within a matrix, composed of an animal basis, solidified by amorphous calcareous matter, the essential element of which is bone-earth, or phosphate of lime. The lacunæ are filled with living animal matter,—germinal matter of Beale,—or cells, which Virchow has shown to be separable from the materials around them by maceration in acids and alkalies, as well as by boiling. The lacunæ communicate with the surface of bone, or with canals occupied by blood-vessels, by means of minute channels, or canaliculi, which are nutrient tubes subservient to the lacunæ, whence they spring.

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* My brother, Mr Joseph Sampson Gamgee, now Professor of Clinical Surgery in Birmingham, recorded a case of Enchondroma of the Testicle, in the *Veterinary Record* for 1850, in which a good description of the cartilage and its union with the fibrous tissue is given:—"Imbedded in the fibrous tissue, and very closely adherent to it, is cartilage. A thin perpendicular section of this texture, with some of the adjoining fibrous tissue, being placed under the microscope, exhibits the true organization of cartilage; 'nucleated cells disseminated in a solid mass or matrix.' Those cells which are deeply seated, *i.e.* at a distance from the free surface, are irregularly oval and spherical, and their outline is indistinct. The nuclei are for the most part coarsely granular, and have a well-defined margin; their extreme measurements in the transverse direction are $\frac{1}{1000}$th to $\frac{1}{5000}$th of an inch. The remark made by Dr Sharpey* may be here with justice repeated, 'that it is often difficult to say whether a body contained within a cartilage cell is its nucleus, or merely the granular contents which have shrunk away from its sides and formed a mass of the same shape as the cell itself, in which the true nucleus is concealed.' In some parts an eccentric nucleolus (from $\frac{1}{3000}$th to $\frac{1}{5000}$th of an inch in diameter) is seen within the nucleus; its outline is well defined, and the interior bright, bearing a resemblance to a particle of fat. It may be well to observe that those nuclei which possess nucleoli are less granular than others. On approaching the surface—which is in contact with the fibrous tissue—the cell-walls are scarcely visible, and some of the nuclei present an elliptical, others a fusiform and almost linear shape. In some parts the fibres may be seen extending in a transverse direction from the adjacent tissue, for a short distance, into the cartilage. A very large proportion of the fibres being rendered indistinct by the action of acetic acid, the cartilage nuclei then come into view; but their shape is so altered (linear), that their real nature can only be inferred by tracing the gradual transition from the oval and spherical shape."

* *Elements of Anatomy.* By JONES QUAIN, M.D. Edited by W. SHARPEY, M.D. and F.R.S., and Mr ELLIS.

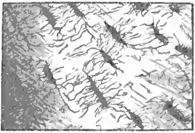

Fig. 43. Lacunæ of bone.

Haversian canals.

The bone-cells vary materially in size in different animals, and are disposed in concentric rings around the Haversian canals, which contain the blood-vessels and nerves surrounded by the marrow. In some parts the canals are very open, and contain much medulla. This is in the inner, open, or cancellated structure, whereas, in the superficial parts of bones—compact tissue—we detect the minute bony cylinders anastomosing with each other, and varying in calibre according to the compactness of bone, placed side by side, and parallel with the direction of the bone.

Thus, the difference between cartilage and bone is chiefly the regularity of the vascular channels, the communication through the matrix by canaliculi between the bone-cells and vascular spaces which travel in close contact with the bony matrix. Lastly, the nature of the matrix, which is always gelatinous—viz., composed of connective tissue, with calcareous particles for the purposes of induration.

Two methods for the production of bone are described. Apparently there are two—viz., intra-membranous production of bone, and intra-cartilagenous. Fundamentally, there is but one, and which consists in the progressive deposition of bone-earth around certain animal cells, which are imprisoned by the advancing bony deposit within the solid matrix of the future bone. The circumstance that all the bony skeleton is cartilagenous in early life, and that the after-growth of bone occurs through the periosteum, or that

Kölliker on the development of bone.

some exceptional cranial bone is never in a cartilagenous state, has naturally led to two methods of ossification being described; but, since our earliest attempts at microscopic investigation, we recognised that the interposition of cartilage in the production of a bony skeleton was simply a means adopted by nature to favour the growth of bones, and also served to preserve the body in a pliant state until after birth. The pliancy of the body in young animals is recognised as one of the most potent causes tending to their preservation, and growth in cartilage is far more rapid than growth in a fully developed bone could be. Referring to the two methods of ossification, Kölliker says: "In both cases, the cells are converted into lacunæ—in the former the cartilage-cells; in the latter the plasm-cells—and this takes place after two somewhat different types. When cartilage ossifies, the cartilage-cells produce a new generation of soft cells, and there only assuming a stellated form, are transformed into lacunæ. On the other hand, when connective tissue ossifies, its cells undergo no greater changes; that is to say, while the fibrous substance of the connective tissue takes up calcareous salts, the cells grow out in a stellate manner, and anastomose, or when they existed as stellate anastomosing plasm-cells, simply remain as such."

Not two methods of development.

When in Paris in 1854, we remember discussing this subject with M. Robin, who at the time agreed with us that the interposition of a cartilage matrix between the production of the original cells and the bony tissue was merely a temporary and not essential occurrence. Fundamentally, there is not an ossification by substitution, or intracartilagenous production of bone, because the matrix of the cartilage so far gives way as to enable the cartilage-cells to become arranged in rows, just as the cells are disposed in a line, with ramifying deposit in the cranial elements. The production of bone is all *by invasion*, or the deposition of calcareous particles, around cells of which there are not two kinds. We have, moreover, never seen the branching of the cells to the extent described by Kölliker and Virchow, and there is probably much truth in Dr Beale's view of this very interesting subject.

Dr Beale's views.

Dr Beale says:—"I have examined the process of ossification as it occurs in various animals with the aid of carmine, and have always been able to demonstrate masses of germinal matter in a position corresponding to the lacunal space. I believe these masses of germinal matter to be as necessary to the production of bone as they are to the formation of every other tissue, and feel certain they are constantly present, and that through their agency alone osseous, as well as all other tissues, is formed. They are not directly concerned in the deposition of the calcareous matter, but the matrix in which this is deposited cannot be formed without them, and it is probable that by their instrumentality alone the regular circulation of fluids holding the calcareous matter in solution is maintained, and thus the extreme regularity with which the growth of the tissue occurs is ensured.

"For some time after the first deposition of the calcareous matter in the formed material very thin fragments of the bone torn away exhibit the appearance of fibres (a fact pointed out many years ago by Dr Sharpey), in the substance of which globules have been deposited but slowly the calcareous matter becomes more homogeueous, in consequence, probably, of changes occurring in its substance, and its more perfect incorporation with the organic matrix, and ultimately the hard mass appears even in texture, uniformly transparent, and penetrated everywhere by minute tubes.

"It seems to me that these tubes are the altered spaces which are left between the calcareous globules originally deposited. They were at first triangular in outline, but gradually they have become altered by the filling up of the angles until at last they become pores, the section of which is nearly circular.

"From appearances I have seen in some preparations of the bones of the frog's skull (frontal, parietal), I feel sure that in their case the bone results from changes in the original cartilage. The nucleus of the cartilage cell remaining as the nucleus in the lacuna. The calcareous matter deposited in the matrix around a cartilage cell undergoes changes, probably slowly, becomes incorporated with the organic matter, and gradually ceases to exhibit the appearance of being composed of separate masses, and becomes more homogeneous. The spaces become canaliculi, and the mass at last assumes the form of perfect bone.

"For some time separate calcareous particles are seen within the outline of the lacunæ, which gradually diminishes in size as calcareous matter is deposited in the matrix from without inwards. . . .

"In the development of the long bones of mammalia, on the other hand, it is equally certain that the spongy, imperfectly formed bone at first developed is gradually removed, and gives place to new bony tissue of a more perfect structure not formed for cartilage, which, as is well known, there are examples of the formation of bone without the existence of cartilage at any period in the case of certain bones of the cranium."

Professor Goodsir on bone development

Professor Goodsir wrote with admirable clearness and correctness on this subject in 1845, and, we think, supports Dr Beale's views, the great difference between the two authorities being in the use of the term cells. Professor Goodsir says:—"The compact osseous substance, in which the corpuscles and their canaliculi are situated, is not homogeneous in texture. It consists of cells filled with bony substance, ossified or calcified primordial cells.

"The soft part of the true osseous texture is not continuous like the hard, but is divided, as has been stated, into as many portions as there are corpuscles in the bone. Each of these portions consists of a little mass of nucleated cells of great transparency. They do not appear to extend along the canaliculi, but to be confined to the cavity of the corpuscle.

Nature of canaliculi.

"These two parts, the hard and the soft combined, constitute the true osseous texture. They differ from one another only in this, that the cells of the one are ossified, those of the other retain their original delicacy and softness. *The masses of soft cells in the corpuscles, I am inclined to consider as the nutritive centres, germinal centres, or germinal spots of the texture.* These centres are the source of all the hardened cells, each of them being the centre of all those comprehended within the range of its own canaliculi. Each of these soft *germinal masses is the centre of attraction for the proper nutriment of bone*, and is the active agent in withdrawing this from the vessels, and appropriating it, partly for the nourishment of the hard cells, each of which has a centre of attraction within itself, but more probably for the formation of new calcigerous cells, as the old cells dissolve and their debris falls back into the returning circulation. *The canaliculi are undoubtedly the principal channels for the passage of nutriment from the capillaries to the calcigerous cells and germinal centres.* They are necessary in a hard texture, and like similar canals and fissures in certain hard cells in vegetables, *only appear at a late stage in the development of bone.* Each osseous corpuscle has its own system of canaliculi, these extending, for the purpose of communicating with others, to the confines of its own territory; that is, to the boundaries of the space which was at one time contained within the sphere of the primary cell of which it was the nucleus."

DENTINE.

Kölliker on dentine.

This substance, which constitutes the bulk of the tooth, is composed of tubes diverging from the pulp cavity, and running side by side until the outer surface of dentine, where lacunæ are seen in the horse and other animals. Around these tubes there is an inter-tubular substance. Kölliker says:—"Dentine, or ivory, may be regarded as a modification of osseous tissue, in which, instead of isolated lacunæ, long canals, the dentinal tubes, occur, and which, also, presents some difference in chemical composition. The mode of its development leads us to regard it as an osseous substance, whose cells have grown out into long tubules, which anastomose with each other by fine processes; a view which also explains the numerous formations observable in animals between the typical dentine and osseous tissue."

Dr Beale on dentinal tubes.

Dr Beale says that he has verified an observation by Mr Jenner, "that the dentinal tubes are occupied with a soft, solid structure, which may be seen projecting in the form of solid processes from the broken ends of the dentinal tubes;" and Dr Beale is very positive in declaring "that the 'dentinal tubes' of a living tooth are never empty; indeed, they are not tubes, nor are they canals for the transmission of nutrient substances, dissolved in fluid, but they contain a soft, solid substance in a state of active vitality."

Dr Beale says:—"The wall of the tube, with the matter between the tubes, correspond to the 'wall' of an ordinary cell, or to this and the inter-cellular substance (my *formed material*), and the contents of the tube to the granular cell-contents with the nuclei (my *germinal matter*.) If you look at the tissue of the pulp just beneath the surface of the dentine, you find a number of oval masses of germinal matter coloured intensely red by carmine. These are nearly equidistant, and separated from each other by a certain quantity of material which is only very faintly coloured, and in cases when the solution was not very strong it remained colourless. This colourless matrix is continuous with the *inter-tubular dentinal tissue*, while the intensely red germinal matter passes into the dentinal tubes. The germinal matter, with a thin layer of soft and imperfectly formed material, is easily detached from the formed material by which it is surrounded, and its continuation with the dentinal tubes may often be torn away. The whole then appears as an oval mass (cell), with a prolongation, as it were, with the dentinal tube."

Dr Beale further adds, that the specimens he has obtained show "that the formation of dentine and the so-called tubes is effected in a much more simple manner than is usually believed. The elongated masses of germinal matter first of all produce *formed material*, which gradually increases, as in other cases, upon the outer surface of the germinal matter. The formed material of the adjacent elementary parts is continuous, and calcareous matter is first deposited in the oldest part of this formed material. The calcareous matter appears in the form of small globules, which gradually increase in size, and often several coalesce. Thus the formed material, or matrix, of the dentine becomes calcified.

"Not unfrequently, however, several of the calcareous globules increase in such a way as to inclose a portion of uncalcified matrix. This being, as it were, imprisoned by hard impermeable structure, retains its soft primitive state. If the tooth be dried, the soft matrix in these spaces shrinks, and air rushes in. Thus the appearance known as 'globular dentine' is produced, and the reason why uncalcified tubes are seen traversing these spaces becomes manifest."

MUSCULAR TISSUE.

Voluntary and involuntary muscle.

This is a highly-organized structure, endowed with the property of vital contractility. It is met with in two forms: 1. The voluntary or striated muscular tissue. 2. The involuntary or cellular. There is an intermediate form which is involuntary, and yet striated; but special characters will be referred to when the anatomy of the heart is considered. Kölliker says that the further our knowledge of the contractile tissue advances, the more clearly does it appear that the decided separation hitherto assumed to exist between smooth and transversely striped muscular fibres can no longer be maintained. He suggests, however, that it is advisable to consider two forms of muscle in man and the higher animals: 1. Those which consist of a cell with one nucleus; and, 2. Those which contain a number of nuclei.

Smooth muscular tissue.

1. Smooth muscular tissue.—This has been described as composed of fusiform cells containing an elongated or cylindrical nucleus, and finely granular matter. They vary in size, and have been classified under three heads, according to their length. The shortest are in the smaller vessels; the middle-sized are in the large arteries and veins; and the largest in the intestine. They are some-

times seen perfectly flat and outstretched, with smooth edges, and under other circumstances they are fringed, or assume a zig-zag form.

This form of muscular fibre is found in the alimentary canal; genito-urinary apparatus; in the trachea and bronchial tubes; in the skin, as well-shown by Mr Lister; in the ducts of the salivary glands, liver, and pancreas; in the envelope and trabeculæ of the spleen; and in the eye.

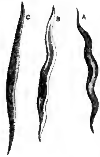

Fig. 44.

Fig. 44. A B C, Plain muscular fibres.

Fig. 45. — SHARPEY.) — Muscular fibrillæ of the pig, magnified 720 diameters. — *a*, An apparently single fibril, showing the quadrangular outline of the component particles, their dark central part and bright margin, and their lines of junction, crossing the light intervals; *b*, A longitudinal segment of a fibre, consisting of a number of fibrils still connected together. The dark cross stripes and light intervals at *b* are obviously occasioned by the dark specks and intervening light spaces respectively corresponding in the different fibrils; *c*, Other smaller collections of fibrillæ, from a preparation by Mr Lealand.

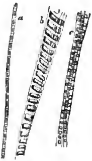

Fig. 45.

Striated muscular fibre.

2. Striated muscular fibre.—This is the ultimate element of the voluntary muscles in the locomotive apparatus. Every muscle is enveloped by a general sheath, from which processes of connective tissue dip onwards, and separate bundles of fibres. These are composed of primitive fibres, or *muscular primitive bundles*, from 0·044‴ to 0·03‴ in thickness, enclosed by a delicate homogeneous envelope or *sarcolemma*. Each fibre is composed of minute fibrils agglutinated together, and which are composed of particles in a row—sarcous elements—which produce the beautiful striæ indicated in the annexed engraving. There is a direct continuity between the sarcolemma and the white fibrous tissue connecting muscle to bone. This

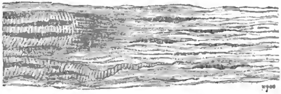

Fig 46.—(BEALE.)—Termination of elementary muscular fibres, and their connection with tendon, magnified 700 diameters. Eye of the frog.—The nuclei of the muscle and those of the tendon are both seen in this drawing.

is beautifully illustrated in Fig. 46, for which I am indebted to Dr Lionel Beale, who has specially investigated this subject.

Striped muscular fibres are met with in trunk and extremities, as well as around the eye and ear. They are also seen in the larynx, pharynx, gullet, rectum, and organs of generation. In the heart and some of the larger veins, there are also striped muscular fibres.

Both striped and unstriped muscular fibres are endowed with the power of contracting, but the first is capable of powerful and sudden efforts under the influence of the will, and the second is usually in a state of rythmic or regular contraction, which are rather slow, and moderate in form.

NERVOUS TISSUE.

No department of animal histology is attended with as much difficulty as that referring to the essential elements of nervous texture. It is this tissue which physiologists would regard as distinctive of an animal organization, and all the phenomena of thought, sensation, and motion in living beings are regarded as essentially dependent on a distinctive nerve-tissue, which does not hold a position in vegetable organisms. There are, nevertheless, instances of susceptibility to impressions (in the sensitive plant) of motion (in ciliated vegetable structures), and even of more wonderful properties, which the so-called vegetable cell enjoys in common with the similar object, the animal cell.

Two elements enter into the constitution of nerves and nervous centres—*cells* and *fibres*. Cells and fibres.

The fibrous constituents are all connected with, or functionally dependent on the nerve-cells. The nerve-cell has been described as Nerve-cells. consisting of an envelope, granular contents, and a nucleus with one or more nucleoli. So far there is no difference between the so-called nerve-cell and any other cell, but it is the great diversity in size, their frequent coloration with pigment, and the brilliancy of a vesicular nucleus, which may be regarded as somewhat characteristic of the nervous elements which are usually stellate, round, or oval, and connected with fibrous prolongations. Some of these cells are as large as $\frac{1}{300}$th of an inch in diameter, and they are not unfrequently as

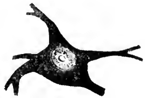

Fig. 47. Nerve-cell.

small as $\frac{1}{3000}$th. Vesicular bodies are interspersed amongst the cellular elements.

Only one essential nervous element.

Varieties of cells have been described, but there appears to be but one essential nervous element. Virchow says:—"It was long believed that essential differences existed between the ganglion cells according as they belonged to one or other of the three principal divisions of the nervous system, and therefore, especially between the cells of the sympathetic and those of the spinal marrow. But in this point also the contrary has proved to be the case, especially since Jacubowitsch has brought to our knowledge the new fact, of the correctness of which I have fully convinced myself, namely, that structures which are perfectly analogous to the ordinary ganglion cells of the sympathetic, also occur in the middle of the spinal marrow and several parts which are considered to belong to the brain."

Nerve-fibres.

The nerve-fibres are found in the nervous centres, and in the nerves which connect the latter with the peripheral parts of the body. They are combined with or spring from the nerve-cells in the grey matter of all nervous ganglia. The ultimate nerve-fibres are of two kinds, tubular or white, and grey or gelatinous. The white have a *special envelope* in the interior of which is Remak's primitive band or axis cylinder (Purkinje), surrounded by a medullary sheath, or *white substance* of Schwann. The tubular fibres have been called medullated by Kölliker, to distinguish them from the non-medullated. The latter occur in organs of special sense, where delicate plexuses are formed, such as in the retina, in the olfactory and auditory apparatuses, and have a structureless envelope, containing a clear granular axis without the *white substance.*

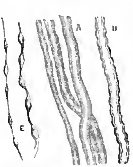

Fig. 48. Tubular or white nerve-fibres. A, indicates the dark outline produced by the medullary sheath after exposure, B, shows the double contours in a nerve-fibre, and E, the varicosities resulting from traction or pressure.

Gelatinous fibres.

Gelatinous fibres have been described by Remak, Henle, and others, which are found associated with the elements already noticed. They are flat, slightly granular, nucleated, and about $\frac{1}{5000}$th of an inch in diameter. Kölliker regards them as constituting a form of connective tissue, and anastomose like the reticulate areolar tissue, but the more recent researches of Dr Beale appear conclusive in favour of Remak's views. In one of his lectures, Dr Beale says:—"The preparations I have shown you compel me to differ from the general opinions now entertained with reference to the nature of the so-called gelatinous or gray fibres. The distribution of these fibres seen in the pericardium, their connection with the ganglia, their constant appearance, the numerous nuclei connected with them, are all incompatible with the notion of their consisting merely of bundles of connective tissue. I can very easily show that many of these fibres are the only fibres connected with most unquestionable ganglion cells, and those who still maintain such fibres to be connective tissue, will, I think, find it very difficult to account for the presence of the ganglia in the number in which they are found in connection with their supposed fibrous tissue. I hold with Remak, and with Todd and Bowman, in this country, that these gray fibres are veritable nerve-fibres, and must be altogether removed from the connective tissue series; moreover, I must add in connection with this question, that the branches of almost all, if not of all nerves, near their termination partake of the characters of the gray or gelatinous fibres." *

Dr Beale, moreover, says, that so far as his researches, still insufficient on this subject, extend, it will be found that the gray or gelatinous fibres are the only ones connected with the round or oval ganglion cells of the sympathetic. Leydig† is of the same opinion.

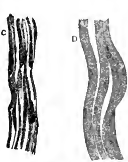

Fig. 49. C D, Remak's gray or gelatinous nerve-fibres.

Chemical nature of nervous tissue.

Nervous matter has a peculiar chemical constitution, which has been very imperfectly made out by chemists. It is believed that the axis cylinder of the tubular fibres is composed of syntorein, a protein compound. The fats, according to Fréury, are olein, oleic and margaric acids, cerebric and oleo-phosphoric acid and cholesterin.‡ "Von Bibra maintains that the brain-fats consist of cerebric acid and cholesterin, and of a series of fatty acids possessing different properties and different fusing points, these fatty acids not even being the same

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* *On the Distribution of Nerves to the Voluntary Muscles.—Phil. Trans.*, 1860.

† *Lehrbuch der Histologie der Menschen und der Thiere.* Frankfort, 1857.

‡ *Physiological Chemistry.* By Dr Day. London, 1860.

in different brains of one and the same species, and (as he conceives), undergoing perpetual decomposition in the living organism passing into one another, and taking a share in the cerebral functions." Amongst the organic constituents of the brain, Müller found creatine in man and not in the ox, a substance similar to leucine in the ox and not in man, lactic acid, inozite, uric acid (ox), certain volatile acids, ascetic and formic acids.

TISSUE OF DUCTLESS GLANDS.

We must include, in a chapter on General Histology, the structure of those remarkable bodies which appear in no way connected with secretion, but rather with changes in the lymph and blood, or of others which secrete, but have no excretory ducts. We cannot, we think, do better than quote Kölliker on the essential glandular tissue of these organs, which presents itself in the following forms:—

Kölliker's classification.

"1. *As a parenchyma of larger or smaller cells*, embedded in a *stroma* of connective tissue. *Supra-renal capsules, anterior lobe of the pituitary body.* Here the cells attain 0·04‴, and more in size; and then contain, besides a granular mass, numerous nuclei and secondary cells.

"2. *As closed follicles*, with *an envelope of connective tissue* and contents consisting of *nuclei*, *cells*, and *some fluid*. To this division I reckon:

"*a.* The *solitary follicles* of the stomach and intestine; and

"*b.* The *aggregated follicles* of the small intestine, or the patches of *Peyer* (in animals, also, of the stomach and large intestine), both of which contain numerous blood-vessels in the interior of the follicles.

"*c.* The *follicular glands of the root of the tongue, the tonsils*, and *the pharyngeal follicles*, which contain, in the walls of their cavities, numerous shut follicles like the above-mentioned, and probably, also, having vessels in their interior.

"*d.* The *lymphatic glands*, the glandular parenchyma of which consists of round follicles, similar to those of the Peyerian glands, but opening into each other, and directly connected with the lymphatic vessels.

"3. *As a cell-parenchyma, supported by the trabeculæ of connective tissue*, containing, like the above, *numerous closed follicles. Spleen.*

"The chemical nature of these more or less vascular organs is still but little known. Those under 1 and 2, as also the follicles of 3, contain much protein and fat in their tissue: while, on the other hand, the rest of the parenchyma of the spleen contains peculiar substances not yet fully investigated, which indicate an energetic process of decomposition. Their physiological functions are just as little known; and it may suffice to mention here, that in the spleen, the thymus, the supra-renal capsules, and pituitary body, it can only be the blood which supplies them with materials, and the blood-vessels and lymphatics which again take up the substance prepared by the glands. In the follicles of the oral cavity and of the fauces, the latter is effused into the larger recesses of these organs, and ultimately into the cavities mentioned; whilst, as to the intestinal follicles, it is doubtful whether they secrete matter into the intestine, or absorb it from the latter and discharge it into the vessels. In the lymphatic glands, the lymphatic vessels conduct their fluid into the glandular follicles and take it up again from them, now rich in lymph-cells. The development of the vascular glands is still very obscure; yet this much appears certain, that they are developed either from the fibrous layer of the intestine, or from the same blastema which produces the sexual glands. The change of material is very energetic in most of these glandular structures, as is shown by their large quantity of blood, and their liability to disease; but the pituitary and supra-renal body may, perhaps, occupy a subordinate position in this respect."

Chemical characters.

Development of vascular glands.

DESCRIPTIVE ANATOMY.

The different parts or organs of the body, are arranged by the anatomist into systems or apparatuses, thus:—

1. The osseous system, or Osteology.
2. The articulations, including the ligaments, or Syndesmology.
3. The muscular system, or Myology.
4. The organs of vegetative life, or Splanchnology.
5. The circulatory system, or Angeiology.
6. The nervous system and organs of sense, or Neurology.
7. The organs of reproduction, or Embryology.

The horse being taken as our standard, we shall point out the peculiarities of form in the other domestic animals.

THE OSSEOUS SYSTEM.—OSTEOLOGY.

The elements of the osseous system are connected together for the protection and support of the soft structures of the body, as well as to give solidity to the limbs for the purpose of locomotion. The bones are in some parts connected by a firm, fibrous tissue, which in process of time becomes ossified, so as to render the union absolutely bony, or are provided with capsules at their ends, and intermediate, rebounding, and smooth layers of cartilage, to favour free gliding motion in various directions, and to a very variable extent. In order to adapt them for very different purposes, bones assume a number of forms. They are:—1. Cylindrical or long, with a firm, compact, but hollow shaft, or *diaphysis*, and two ends, or *epiphyses*. The upper epiphysis is usually termed the head of the bone. The term epiphysis is applied to either end in early life, before the bones are consolidated. They are bulky, and covered over their joint surfaces by cartilage. The hollow shaft of long bones contains the marrow. 2. Short bones, such as the bones of the horse's knee, or carpus, are angular, and sometimes termed round bones. 3. Irregular bones are such as can-

Long bones.

Short bones.

Irregular bones.

Flat bones.

not be termed long or short, and have a very remarkable complexity in form. The vertebræ are irregular bones. 4. Flat or tabular bones, such as the cranial elements or the shoulder-blade, are of the shape their name implies.

Perforations in bone.

All bones have perforations into them for the passage of nerves and blood-vessels. These are foramina. A *foramen* or *hiatus* may lead into a *canal* (*e.g.*, the lacrymal canal) or *aqueduct* (*e.g.*, the aqueduct of Fallopius). The term *meatus* is also applied to a bony passage (meatus auditorious). Depressions on the surface of the bone receive the names of *fissure*, *sulcus* (sulci meninges of the cranial bones), *fossa* (supra-condyloid fossa of the femur). In some instances, as in the bones of the skull, space is left between bony plates, constituting what is called a *sinus* or *antrum*.

There are cavities on the joint surfaces, termed glenoid when shallow, and cotyloid when deep.

Bony processes.

In long bones there are usually certain processes—apophyses—jutting out in the shape of a *tubercle* or *trochanter*. Sometimes the eminence is in the form of a *crest* or *ridge*. I have before said that the upper epiphysis constitutes the head of a long bone, but anatomically the head is only the prominent rounded portion, articulating with the adjoining bone, and separated by a *cervix* or *neck* from all beyond the articulation. Thus in the femur the anatomical head is enclosed in the acetabulum, whereas the prominent trochanters, connected with the upper epiphysis, constitute part of the head in surgical anatomy. The lower portion of a bone, such as the humerus or femur, is extended for the purposes of articulation by eminences, termed *condyles*. A *spine* is a sharp ridge or prominent process from a bone.

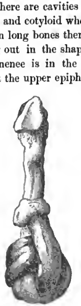

Fig. 50. (Dalton.)

Chemical nature of bone.

Every bone is composed of an animal gelatinous basis, which, in the analyses of older chemists, is always stated as cartilage; with this the earthy and other constituents are intimately blended, so that if a bone is burned, the shape is preserved by the earthy residue, though liable to crumble on the slightest touch. Moreover, if a bone be steeped for some time in dilute hydrochloric acid, the earthy substance dissolves out of it, and the animal basis retaining the perfect shape of the bone may be twisted about in any form, as shown in the engraving (Fig. 50).

Bones of the horse.

Von Bibra analysed the compact and spongy substance of the femur of a horse aged 12 years, and obtained the following results:—

	Compact Substance.	Spongy Substance.
Phosphate of lime with a little fluoride of calcium	54·65	41·14
Carbonate of lime	11·74	18·93
Phosphate of magnesia	1·48	1·32
Salts	0·86	0.94
Cartilage	31·27	37·67

Ruminant's bones.

The same chemist ascertained the composition of bones in ruminants to be as follows:—

	Sheep aged 1 year.	He-goat.	Bull aged 4 years.		
	Femur.	Os occip.	Femur.	Tibia.	Os. occip.
Phosphate of lime with a little fluoride of calcium	55·94	47·07	54·07	54·03	52·51
Carbonate of lime	12·18	9·09	12·71	11·99	11·14
Phosphate of magnesia	1·00	1·59	1·42	1·44	1·05
Salts	0·50	1·02	0·80	0·70	0·50
Cartilage	29·68	39·58	29·09	29·92	32·80
Fat	0·70	1·65	1·91	1·92	2·00

Considerable diversity exists in the constituents of the bones at different periods of life. In young animals there is a large proportion of the gelatinous basis, and comparatively less earthy matter. Of the earthy salts, the chief is always true earth or phosphate of lime, but this is far more in excess of other salts in very young animals than in adult ones. Carbonate of lime increases with age. These points are shown by the following analyses, also made by Von Bibra:—

	Horse (fœtus of about 3 months.)	Castrated horse aged 6 years.		Mare aged 14 years.
	Humerus and tibia.	Femur.	Humerus.	Femur.
Phosphate of lime with a little fluoride of calcium	60·51	54·37	52·86	54·63
Carbonate of lime	1·83	12·00	12·00	11·28
Phosphate of magnesia	1·40	1·83	1.75	1·50
Salts	a trace	0·70	0.71	0·40
Cartilage	36·26	27·99	29·70	27·98
Fat	—	3·11	2·91	4·21

Proportions of earthy and animal matter.

The proportions of earthy and animal matter vary singularly according to the food animals partake of. In herbivora there is far

Bones in disease. more carbonate of lime than in carnivora, and in disease remarkable changes occur of which we have a good instance in the "Cripple," or Cachexia Ossifraga of cattle in certain farms where the soil and crops are deficient in lime. My brother, Mr Arthur Gamgee, made the following quantitative analysis of the diseased femur of a cow that had died from this disease, and for the sake of contrast, we place by its side the composition of healthy bone:—

	Diseased Bone.	Healthy Bone (Von Bibra.)
Organic constituents	36·50	31·00
Phosphate of lime, with a little phosphate of magnesia, and fluoride of calcium . .	51·90	55·49
Carbonate of lime	9·80	12·71
Soluble salts	1·80	0·80

In various parts of the continent of Europe considerable attention has been paid to this disorder; and in the 9th volume of the *Berlin Veterinary Magazine*, we find that Dr Kreuscher of Bingen has carefully examined the bones both as to their physical and chemical constitution. He refers to the cancellated structure having increased, and the compact bone becoming porous. The bony canals disappear. The bones contain much moisture, are light, and crumble. Their specific gravity he states as varying from 10 to 15 per cent. less than the bones of healthy animals.

ANALYSIS.

	Diseased Bones.		Healthy Bones.	
	Earthy substances.	Animal matter.	Earths.	Animal basis.
Femur . . .	32·50	67·50	60·02	39·98
Ribs . . .	30·00	70·00	57·49	42·51
Vertebra and pelvis .	26·13	72·87	57·42	42·58

Of the earthy principles only 78 per cent. of phosphate of lime existed in the diseased bones, whereas 86 per cent. is the proportion in health.

The chemical constitution of bone indicates that it is admirably adapted for resistance, toughness, with a certain degree of elasticity, Colour of bone. beautifully exemplified by the ribs, Bone, when recent, is covered by a very vascular membrane—periosteum—and if stripped of this, is seen of a red colour. When macerated, they become of a dull white colour. The bones of old horses are very apt to be of a dark yellow colour, owing to the large quantity of fat they contain, a circumstance that has been noticed by Von Bibra.

Cancellated tissue.

If a bone is sawn or broken in two, it is found to be composed of an outer compact substance, and an inner open or cancellated structure. In flat bones, the latter is termed *diploë*, and the compact material is disposed in the form of two layers. In long bones, the compact tissue is most abundant about the middle of the shaft, at which part the cancellated tissue is scanty, and, indeed, its place is occupied by the marrow, in the medullary canal. Towards the ends, the compact layer becomes thin, and the cancellated tissue acquires great proportions. By the cylindrical shape of long bones, the nature of the marrow, and the porous character of the bulky ends, the greatest degree of toughness and strength is ensured, with the smallest amount of bony material.

Compact tissue.

Haversian canals.

The compact tissue of bone is observed to be very firm and solid in thoroughbred horses, and some of the fleet ruminantia such as the red deer. Nevertheless, on any part of its surface, minute apertures may be detected, especially with the aid of a pocket lens. These lead into canals, termed (after Clopton Havers, a physician who lived in the 17th century), Haversian canals. They vary from $\frac{1}{300}$th to $\frac{1}{1200}$th of an inch in diameter, being much smaller in the thoroughbred than in low-bred horses.

Medullary spaces.

A longitudinal section of bone, examined microscopically, indicates that these canals are short, and freely anastomose. They are separated from each other by laminæ, arranged concentrically around each canal, as shown best by a transverse section (Fig. 51.) As the Haversian canals are arranged, any bone may be compared to a mass of innumerable cylinders, disposed in the same direction as the bone, and the cavities of which coalesce. In flat bones the canals run parallel to their surface, or radiate from centre to circumference. Towards the medullary canal, the Haversian tubes increase in diameter, and at the ends of bone they abut in infundibulorm cavities, or medullary spaces. They have been termed Haversian spaces by Tomes and De Morgan.

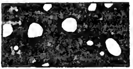

Fig. 51. Transverse section of Radius of horse.

The concentric arrangement of the bony lamellæ around the Haversian canals is very readily observed, from the peculiar position of the bone cells, which appear dark with transmitted, and white by reflected light.

Canaliculi.

The lacunæ have delicate tubes—canaliculi branching from them

Contents of lacunæ.

towards the Haversian canals, or anastomosing with the canaliculi of neighbouring lacunæ. Every lacuna is occupied by a soft animal matter—Beale's germinal matter—or bone-cells. The canaliculi are supposed to be nutrient tubes, conveying material from the Haversian canals to the laminæ.

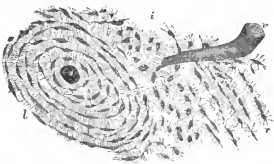

Fig. 52.—(VIRCHOW.)—Section of Bone. *a*, Transverse section of medullary (vascular or Haversian) canal, around which the concentric lamellæ lie with bone corpuscles and anastomosing canaliculi; *r*, Lamellæ divided longitudinally and parallel. *i*, Irregular arrangement in the oldest layer of bone. *v*, Vascular canal. × 280.

Osseous lamellæ.

By peeling the periosteum off the surface of bone in a longitudinal direction, delicate portions of osseous lamellæ are obtained. These are arranged, as Kölliker says, in two systems, "a general, which runs parallel to the outer and inner surfaces of bones, and many special, surrounding the separate Haversian canals." These systems, it is true, are in many places immediately connected with each other, but for the most part are only in apposition, and can therefore be conveniently regarded as being of two kinds, which view is also to some degree supported by their mode of development.

Sharpey on lamellæ.

Sharpey has given an excellent description of the lamellæ. He says:—"The lamellæ are seen to be perforated with fine apertures placed at very short distances apart. These apertures were described by Deutsch,* but they have not much attracted the notice of succeeding observers; they appear to me to be the transverse sections of the canaliculi already described, and their relative distance and position accord sufficiently with this explanation. According to this view, therefore, the canaliculi might (in a certain sense) be conceived to

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* *De Penitiori Ossium Structurâ.* Wratisl. 1834, p. 17, fig. 6.

Apertures and canaliculi.

result from the apposition of a series of perforated plates, the apertures of each plate corresponding to those of the plates contiguous with it; in short, they might be compared to holes bored to some depth in a straight or crooked direction through the leaves of a book, in which case it is plain that the perforations of the adjoining leaves would correspond; it being always understood, however, that the passages thus formed are lined or bounded by membranous parietes.

Fibres of lamellæ.

"But the lamellæ have a further structure. To see this the thinnest part of a detached shred or film must be examined, as shown in Fig. 53; it will then appear plainly that they are made up of transparent fibres, decussating each other in form of an exceedingly fine net-work. The fibres intersect obliquely, and they seem to coalesce at the points of intersection, for they cannot be teased out from one another; but at the torn edge of the lamella they may often be seen separate for a little way, standing out like the threads of a fringe. Most generally they are straight, as represented in the figure; but they are not always so, for in some parts they assume a curvilinear direction. Acetic or hydrochloric acid causes these fibres to swell up and become indistinct, like the white fibres of areolar and fibrous tissue; care must therefore be taken, in their examination, that the remains of the decalcifying acid be removed from the tissue, by maceration in water or in solution of an alkaline carbonate. Moreover, the fibro-reticular structure is not equally distinct in all parts where its presence is recognisable; for in some places it is less decidedly marked, as if the fibrilation were incompletely developed—resembling in this respect the areolar and fibrous tissues.

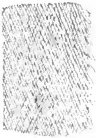

Fig. 53. (Sharpey.)—Thin layer peeled off from a softened bone, as it appears under a magnifying power of 400. The figure, which is intended to represent the reticular structure of a lamella, gives a better idea of the object when held rather farther off than usual from the eye.

Perforating fibres.

"In many instances the lamellæ are perforated by fibres, or rather bundles of fibres, which pass through them in a perpendicular, or more or less oblique direction, and, as it were, bolt them together. These *perforating fibres* may be seen, with the aid of the microscope, in a thin transverse slice of a decalcified cylindrical or cranial bone, on pulling asunder the sections of the lamellæ."

In addition to the lamellar structure, Sharpey notices:—1. Flattened cells in strata, at or near the surface of the compact tissue of the shaft in cylindrical bones; and, 2. True cartilage calcified immediately beneath the articular cartilage. The calcareous matter in this part is deposited in the matrix of the structure.

Periosteum.

Periosteum.—This is a fibrous membrane, chiefly composed of condensed areolar tissue externally, and of elastic membrane within. It is a bed for the ramification of blood-vessels and nerves, which pass from the periosteum into the bone covered by the latter. This circumstance it is that renders it so dangerous to strip any considerable portion of periosteum off bone. It is probably prolonged into the Haversian canals, and continuous with the membrane lining the medullary canal, which has been called endosteum or internal periosteum. This delicate layer of vascular connective tissue encloses the marrow, which is composed of fatty tissue.

Endosteum.

Blood-vessels of bone.

Bone is amply supplied with blood-vessels. The arteries within its substance are either branches of periosteal vessels, or of the nutrient artery of the bone. "The venous blood," says Kölliker, "passes out of every long bone at three places: 1. By a large vein which accompanies the arteria nutritia, and has the same distribution; 2. By numerous large and small veins at the articular extremities; 3. By many small veins, which arise independently, from the compact substance of the shaft, in which their roots, as Todd and Bowman correctly pointed out, occupy the wider spaces, and the sinus or pouch-like excavations, as may be well seen in polished sections of bone." There is probably a very free communication between the different parts of the vascular system of a bone. In the cranial bones, the veins (venæ diploëticæ) branch outwards, from centre to circumference, in arborescent canals, which open by large apertures (emissoria Santorini).

Lymphatics.

It is doubtful whether lymphatics exist in bone. They have been traced in the connective tissue around the joints.

Nerves.

Nerves ramify in the periosteum, and penetrate the Haversian canals, appearing most numerous towards the articular ends of the long bones.

Development of bones.

Development of the Bones.—We have already alluded to this subject in the General Histology, and have now to describe more particularly the changes which occur in the production of the different elements of the skeleton. In the material which aggregates or developes in fœtal life, in the form of the future bony framework, elasticity and sufficient solidity are ensured by the production of cartilage, or, in other words, the cells or germinal matter multiply and advance in growth, so as to produce a small amount of matrix or intercellular substance, which breaks up when the process of ossification progresses with activity. In the cranium, a fibrous capsule occupies the position of the future bones, and this has led to the description of two processes of ossification, intra-cartilaginous and intra-membranous. It is, however, the same embryonic cell, the same germinal matter which determines the position and structure of all the future bony elements.

Centres of ossification.

The production of bone occurs from definite spots, which are termed nuclei or centres of ossification (puncta ossificationis). These centres are very constantly the same—one occurring in the long bones for the diaphysis, another for each epiphysis, and others for any marked apophysis. It is not always in the substance, but often on the surface of the fœtal cartilage, that ossification commences. Kölliker mentions, in his *Microscopic Anatomy*, that recent observations of H. Müller show that the first ossification in the diaphyses of the long bones of the calf takes place in the outermost parts of the cartilage, if not in the periosteum itself. The first rudiments of the femur, for instance, have the form of a short tube surrounding the primordial cartilage. Howship had indicated the same circumstance regarding the metacarpal and phalangeal bones of the human embryo. In all animals, as we shall afterwards see, the growth of bone in circumference, after the complete ossification of the original cartilage, occurs through the periosteum.

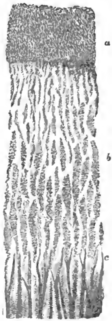

Fig. 54.—(Sharpey.)—Thin longitudinal section of ossifying cartilage from the humerus of a fœtal sheep, magnified about 70 diameters. *a*. Cartilage cells uniformly diffused. *b*. Cells nearer the surface of ossification, collected into piles or oblong groups. *c*. Bone shooting up between the groups of cells and forming oblong areolæ.

Development of bone from cartilage.

Whether the development of bone occurs in the cranial membranes or cartilages of the extremities, whether it commence in the substance or on the surface of any cartilaginous element, there is a determination of blood to the spot. The cartilage or membrane becomes red and vascular. The matrix of the cartilage becomes soft, or rather it is evident, from the fact that the cartilage cells become arranged in rows, that these are not fixed by a solid intercellular substance. The rows of cells are disposed in a line with the directions of the growing bone, or radiating from the centre in irregular and flat bones. Bright, shining fibres, resulting from the deposition of calcareous salts, are seen shooting forward between the cells, and enclosing not only the latter but the blood-vessels. A network of bony spiculæ is thus obtained, in which the spaces are large, and filled by soft formative or germinal matter, situated with the blood-vessels in the centre. Earthy matter continues to be assimilated by the living material, thus beautifully disposing itself, and the bony laminæ get built necessarily one within the other, until the blood-vessel is reduced to the minimum size which it is to retain for the nourishment of the bony tissue. There is no doubt that the lacunæ are spaces between the layers of calcareous deposit, determined by the numerous nuclei or germinal centres, which are arranged around the blood-vessels, and the development of the canaliculi evidently depends, as Dr Beale has explained, on the constant imbibition of nutrient matter by the lacunæ, thus keeping up a connection, and causing the persistence of spaces between the blood-vessels and the bone-cells.

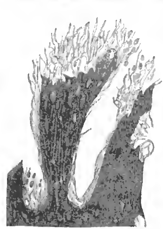

Fig. 55. — (Sharpey.) — The growing ends of two bony spicula from the frontal bone of an embryo dog, highly magnified. The surrounding membrane has been removed, and most of the corpuscles are washed away, to shew more evidently the transparent soft fibres prolonged from the bone, with the dark earthy deposit advancing into them.

Development of cranial bones.

The difference between the development of the flat cranial bone in a membrane, and the transformation of one of the fœtal cartilages, only consists in the direction of the canals and blood-vessels, in accordance with the shape of the bone. The process described goes on until the fœtal membrane or cartilage is totally transformed, or as in the case of the long bones, until the diaphysis and epiphyses are joined by a thin layer of cartilage tissue. The changes which succeed are due to deposition or growth from the periosteum as shown by Dr Sharpey, as well as to additional material being produced at the ends of the shaft. Within the vascular periosteum is an active layer of formative material, in which precisely the same changes are occurring as in the original points of ossification—that is to say, blood-vessels are being progressively enclosed into canals by depositions around them, the arrangement of which is determined by nuclei or cells. Kölliker and Virchow believe that these cells, without previously presenting secondary membranes, like the cartilage capsules, gradually acquire a stellate form, and when the surrounding matrix ossifies, become directly transformed into stellate bone-cells, which, accordingly, are not contained in bone-capsules. Dr Beale says, and I believe him to be perfectly correct, that the stellate appearance is owing to the manner in which the calcareous matter is deposited in the formed material, and not upon any alteration in the form or position of the cells or nuclei.

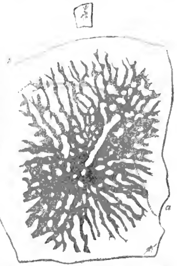

Fig. 56.—(Sharpey.)—Parietal bone of an embryo sheep; size of the embryo, 2¼ inchse. The small upper figure represents the bone of the natural size; the larger figure is magnified about twelve diameters. The curved line *a*, *b*, marks the height to which the subjacent cartilaginous lamella extended. A few insulated particles of bone are seen near the circumference—an appearance which is quite common at this stage.

Moreover, Dr Beale says:—"As far as I have been able to see, neither the cartilage cell, nor the medullary cell, nor the periosteal cell, nor indeed any cell in the organism becomes stellate by the 'shooting out process.' That cartilage and the other 'cells' may become angular is perfectly true, and that a few little projections may be seen from different parts of their surface is also true, but these projections and angles have nothing to do with the formation of canaliculi. The appearance is exceptional instead of being constant, and a lacuna with numerous canaliculi may be produced without the existence of an angular cell at all. The mass of germinal matter is oval from the period it first existed as a separate object to the time its nucleus is seen in the lacuna. Into each lacuna forty or fifty or more canaliculi open, and these communicate with those of adjacent lacunæ. Surely, if these were formed in the manner described we ought to be able to demonstrate something like this during the formation of the lacunæ, but nothing of the sort has been seen, and the warmest advocates of the theory have only been able to observe a very faint indication of the arrangement which they believe actually exists. Their drawings only show these processes projecting a very short distance from the cells, and no one, I believe, ever pretends to have seen processes from two neighbouring cells in process of communicating with each other, as exists constantly in the perfect canaliculi of bone. It is not only very difficult to conceive such channels formed by an out-growth, but it is inconsistent with what is generally observed, to suppose that channels are scooped out in a tissue which has just been formed. The tissue, *during its formation*, requires channels for the transmission of nutrient matter just as much as after its formation is complete.

"If the canaliculi were formed as described, it is quite impossible that every observer should have failed to see the prolongations of the cell undergoing development, and coalescing with those of neighbouring cells. The extremities of these tubes which were gradually extending through the matrix would be rounded, and would contain germinal matter which would absorb the solid matrix, and thus the tube would extend through its substance. No such appearance has ever been seen. The canaliculi are no more processes of the cell which bore their way through the hard material, than the tubes which are found in the masses of secondary deposits in the hard walls of certain vegetable cells are processes of the germinal matter in the centre of the cell.

"In both cases the tubes do not result from the outward growth of processes of the cell, but they are mere channels which are left for the transmission of nutrient material during the impregnation of the formed material, with an impermeable, or almost impermeable, deposit. They are formed as the hard material is deposited, and the deposition of this takes place from without inwards. The length of the tubes increases as the cavity in the centre of the hard material diminishes, but the distance of the end of the canaliculus, or rather the point where it is continuous with the canaliculi of adjacent lacunæ, from the centre of the space, remains the same from the first, measuring in a direct line."

Formation of medullary cavity. As the bone increases in thickness, the first-formed portions in the centre give way, and there is a progressive absorption within corresponding to the deposition outside. Thus the medullary cavity is formed. At the same time the epiphyses grow, so that the bone increases in length by addition at its ends, just as it grows in breadth by addition to its surface. Growth.

When bones are fractured, union readily occurs in all our domestic animals. If the fractured ends are retained in a fixed position, the fracture having been properly reduced, the union occurs without any deformity, or even thickening, at the seat of union, but as we more commonly see in the lower animals, very extensive deposition occurs around the broken ends, when reduction is not complete, or the parts are not fixed. The formation of bone from the periosteum is beautifully exemplified in necrosis and other bone diseases. Union of fractured bones.

SKELETON OF THE HORSE.

The Frontispiece of this Work affords our readers an opportunity of examining the most satisfactory drawing of a horse's skeleton which we believe to have been produced. Very considerable defects have been overlooked in plates hitherto published, and which consist chiefly in the spinal curves having been drawn to an artist's fancy, and the limbs being wrongly placed. The direction of the individual bones, and the angles formed by them in the extremities, are, without a single exception that we are aware of, false in Atlases and Treatises, British or Continental.

Two circumstances have favoured the preparation of a reliable Plate appended to this work. The first is the possession of the beautifully proportioned natural skeleton of *Eclipse*, in which the direction of the spine and the relations of the bones have been preserved by the only possible way, their natural ligaments. The skeleton has been drawn to a scale of one-tenth, and it will be found that the measurements of the bones correspond with those given by VIAL DE ST BEL in his work on the proportions of *Eclipse*.

When we first measured the bones of this celebrated horse, we could hardly reconcile some measurements with numbers given in VIAL DE ST BEL's work. The head, scapula, humerus, femur, and tibia, corresponded at once, as, indeed, the total length of the limbs; but ST BEL, in measuring the *cubitus* and the *cannon bone*, evidently made an arbitrary division between the two regions at the middle of the carpus, as he has not given us the measurement of the latter, but the former correspond to the arbitrary division he made. Moreover, we know that the height of *Eclipse* was about 15 hands two or three inches. The skeleton is drawn to this height, though ST BEL somehow or other states that the horse was 66 inches high on the withers, and 67 on the rump, a measurement which in no way corresponds with the length given by him of the bones of the fore-limbs; it is a decided error, as we find it to be 62 inches in height, and without any appreciable difference between the measurement of the withers and that of the rump, which would make *Eclipse* about 15 hands 3 inches high.

We may mention that VIAL's measurements of the regions of *Eclipse* by so many heads, are perfectly correct in every particular. We have, however, not elevated *Eclipse's* head as he has done in the diagrams introduced into his work.

The second circumstance which has favoured the preparation of the frontispiece is the skill brought to bear on it by Mr CLARK STANTON, who has specially studied the anatomy of the horse, with a view to correct drawing and modelling.

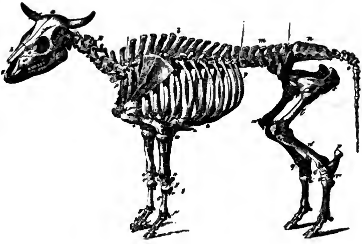

Fig. 57. SKELETON OF THE COW.

Bones of the Cranium.—Occiput—Frontal, *a*; Parietal, *b*; Temporals, *c*; Sphenoid and Ethmoid.

Bones of the Face.—Nasal, *h*; Lachrymal, *e*; Malar, *d*; Superior maxillary, *f*; Anterior maxillary, *g*; Inferior maxillary, *i*; Vomer, Palatine, and Hyoid Bones.

Vertebræ.—Cervical, *k*, 7 in number; Dorsal, *l*, 13; Lumbar, *m*, 6; Sacrum, *n*, 1; Coccygeal bones, *o*, 20.

Bones of the Trunk.—Ribs, *p p*, 26. Sternum—Ileum, *q*; Pubis, *r*; Ischium, *s*.

Bones of the Limbs.—Fore limb—Scapula, *t*; Humerus, *u*; Radius, *v*; Ulna, *w*; Carpal bones, *x*, *y*, *z*, *a′*, *b′*, *c′*; Large metacarpal bone, *d′*; Small metacarpal bone, *e′*; Sesamoids, *f′*; Os suffraginis, *g′*; Os coronæ, *h′*; Pedal bones, *i′*; Navicular bones, *k′*. Hind limb—Femur, *o′*; Patella, *m′*; Tibia, *n′*.

Bones of the Hock, *o′*, *p′*, *q′*, *r′*, *s′*, *t′*.

Below the hock the number and disposition of the bones is similar to the fore limb.

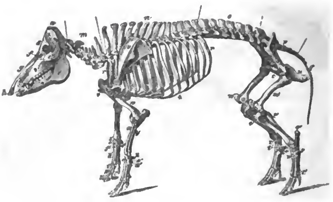

Fig. 58. SKELETON OF THE PIG.

Bones of the Cranium.—Occiput, *a*; Parietal, *b*; Frontal, *d*; Temporal bones, *c*; Sphenoid and Ethmoid.

Bones of the Face.—Nasal, *g*; Snout bone, *h*; Lachrymal, *f*; Malar, *e*; Superior maxillary, *i*; Anterior maxillary, *k*; Inferior maxillary, *l*; Hyoid bone.

Vertebræ.—Cervical, *m*, 7; Dorsal, *n*, 14; Lumbar, *o*, 7; Sacrum, *p*; Coccygeal bones, *q*, 18 in number.

Bones of the Trunk.—Ribs, *r r*. Sternum—Ileum, *s*; Pubis, *t*; Ischium, *u*.

Bones of the Extremities.—Fore limb—Scapula, *v*; Humerus, *w*; Radius, *x*; Ulna, *y*; Carpal bones, *z*, *a'*, *b'*, *c'*, *d'*, *e'*, *f'*, *g'*; Metacarpal bone, *h'*. Splint bones—First phalanges, *i'*; Second phalanges, *k'*; Third phalanges, *l'*. Hind limbs—Femur, *m'*; Patella, *n'*; Tibia, *o'*; Fibula, *p'*. Bones of the Hock, *q'*, *r'*, *s'*, *t'*, *u'*, *v'*, *w'*. The phalanges are similarly disposed in the hind as in the fore limbs.

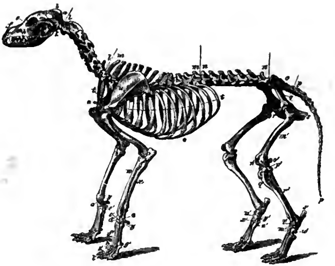

Fig. 59. SKELETON OF THE DOG.

CRANIAL BONES.—Occiput, *a*; Parietal, *b*; Frontal, *c*; Temporals, *k*; Sphenoid and Ethmoid.

FACIAL BONES.—Nasal, *f*; Lachrymal, *e*; Malar, *d*; Superior maxillary, *h*; Anterior maxillary, *g*; Inferior maxillary, *i*; Hyoid.

VERTEBRÆ.—Cervical, 17; Dorsal, *m m*, 13; Lumbar, *n n*, 7; Sacrum, *o*; Coccygeal bones, 20.

BONES OF THE TRUNK.—Ribs, *t t*, 26. Sternum—Ileum, *q*; Pubis, *r*; Ischium, *s*.

BONES OF THE LIMBS.—Fore limb—Scapula, *u*; Humerus, *v*; Radius, *w*; Ulna, *x*; Carpal bones, *y*, *z′*, *a′*, *b′*, *c′*, *d′*, *e′*; Metacarpal bones, *f′*, *h′*, *g′*; First phalanges, *i′*; Second phalanges, *k′*; Third phalanges, *l′*. Hind limb—Femur, *m′*; Patella, *n′*; Upper sesamoid bone of stifle, *o′*; Lower sesamoid of stifle, *p*; Tibia, *q′*; Fibula, *r′*; Tarsal bones, *s′*, *t′*, *u′*, *v′*, *w′*, *x′*, *y′*. The metatarsal bones and phalanges correspond to the metacarpal bones and phalanges of the fore limb.

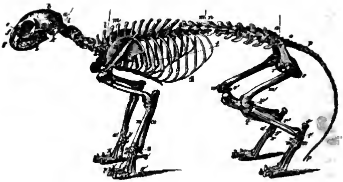

Fig. 60. SKELETON OF THE CAT.

BONES OF THE CRANIUM.—Occiput, *a*; Parietal, *b*; Frontal, *c*; Temporal, *k*; Sphenoid and Ethmoid.

BONES OF THE FACE.—Nasal, *f*; Lachrymal, *e*; Malar, *d*; Inferior maxillary, *h*; Anterior maxillary, *g*; Lower jaw, *i*.

VERTEBRÆ.—Cervical, *l l*, 7 in number; Dorsal, *m m*, 13; Lumbar, *n n*, 7; Sacrum, *o*; Coccygeal bones, *p p*, 20.

BONES OF THE TRUNK.—Ribs, *t t*, 26. Sternum—Ileum, *q*; Pubis, *r*; Ischium, *s*.

BONES OF THE EXTREMITIES.—Fore limb—Scapula, *u*; Humerus, *v*; Radius, *w*; Ulna, *x*; Carpal bones, *y*, *z*, *a'*, *b'*, *c'*, *d'*, *e'*; Metacarpal bones, *f'*, *g'*, *h'*; Phalanges, *i'*, *k'*, *l'*. Hind limb.—Femur, *m'*; Patella, *n'*; Upper sesamoid of stifle, *o'*; Inferior sesamoid, *p'*; Tarsal bones, *s'*, *t'*, *u'*, *v'*, *w*, *x'*, *y'*; Metatarsal bones. Phalanges as in the fore limbs.

OSTEOLOGY.

Uses of the skeleton. **Natural and artificial skeleton.**

EVERY vertebrate animal possesses a bony framework, which is destined to support the soft structures, to afford a series of unyielding levers, in the construction of the locomotive apparatus, and to form several cavities for the enclosure and protection of vital organs. To fulfil these various purposes, bone is peculiarly adapted by its toughness, hardness, and resiliency. The whole bony structure of the body, when divested of the soft parts which normally envelope it, is called the skeleton (σκέλλω, to dry). When its various parts are kept in apposition by the ligaments that bind them together in the living animal, the preparation is called a *natural skeleton*. When divested of these ligaments, and connected by iron wires or other means, it is called an *artificial skeleton*.

Vertebral column. **Head, ribs, and pelvis.**

The skeleton is composed of symmetrical elements which form the framework of the limbs, and all such elements are joined immediately or mediately to a central chain of bones which runs in an antero-posterior direction throughout the entire body. This important chain, called the *vertebral column* or back bone, is the most characteristic part of the skeleton of vertebrate animals, and that which is first developed in the embryo. At its anterior extremity is placed the head; attached to the sides of its middle part are the ribs; while more posteriorly, and still laterally, are appended the innominate bones. The ribs contribute to the formation of a large cavity for the protection of the heart and lungs, and to the lateral parts of which the fore limbs gain attachment; the innominate bones assist in forming the pelvis, which, besides protecting important organs, gives a solid point of attachment to the hind limbs.

Various views of the skeleton.

By the anthropotomist or hippotomist, each of which confines his attention to the anatomy of a single species, the skeleton is commonly divided into trunk and extremities, and each bony element is considered in various senses, as, *e. g.*, its position, direction, relation, external conformation, internal structure, development, &c. The comparative anatomist, on the other hand, embracing, as he does, the whole animal creation in his researches, has been enabled, from the examination of their analogies and points of difference, to demonstrate an admirable order and harmony in what had else appeared the veriest chaos, and to illustrate homologies existing between the different parts of the same body, the study of which is at once interesting and instructive.

Bony systems in the animal creation.

The component parts of the skeleton in the whole class of vertebrate animals are comprised in four great systems, called respectively the *endoskeleton*, the *exoskeleton*, the *splanchnoskeleton*, and the *scleroskeleton*. The first of these is the only one claiming our especial attention, as the three last exist only in a very rudimentary condition in any of our domestic quadrupeds.

Internal skeleton.

Aggregate of like parts.

Variations at different parts.

The *endoskeleton* (ενδος, within), called also *neuroskeleton* (νευρων, a nerve), is common to, and forms the most essential part of the skeleton in, all vertebrata. It consists of an aggregation of segments or individual vertebræ, each of which is more or less developed, according to the species of animal and the region of the body in which it may be placed, but in all cases having the representatives of its various parts in an ideal typical vertebra, constructed by the comparative anatomists as the result of their investigations.

Typical segment, has body, two rings, and processes.

The typical vertebra consists essentially of a central solid part or body, with a superior or neural arch, an inferior or hæmal arch, and various processes. The understanding of these parts will be facilitated by a reference to the adjoining cut. In this ideal vertebra, C represents the body or *centrum;* N, the neural arch; and H, the hæmal arch.

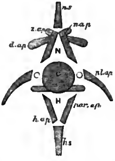

Fig. 61. (QUAIN and SHARPEY.)—In this diagram the elements of a complete vertebra are seen; and in the subjoined references to it, their designations are explained:—C centrum (κεντρον, centre); *par. ap.* parapophysis (παρα, across); *pl. ap.*, pleurapophysis (πλευρα, rib, αποφυω, to grow out.) N neural ring (νεῦρον, neve); *n. ap.*, neurapophysis; *n. s.*, neural spine; *d. ap.*, diapophysis (δια, across); *z. ap.*, zyapophysis (ζυγος, junction. H hæmal ring (αἷμα, blood); *h. ap.*, hæmapophysis; *h. s.*, hæmal spine.

Body and rings.

Diapophysis.
Neurapophysis.
Zygapophysis.
Neural spine.
Parapophysis.
Hæmapophysis.
Hæmal spine.
Pleurapophysis.
Epapophysis and hypapophysis.
Autogenous elements.
Exogenous elements.

Beside the body, the following parts will be observed to enter into the formation of the neural arch:—*diap.*, the diapophysis (δια, across, αποφυω, to grow out), or transverse process of the ring; *n. a. p.*, the neurapophysis; *z*, the zygapophysis (ζυγος, junction); and *n. s.*, the neural spine. The union of the following parts with the centrum forms the hæmal arch:—*par. ap.*, the parapophysis (παρα, across), or transverse process of the body; *h. ap.*, hæmapophysis (αἷμα, blood); and *h. s.*, the hæmal spine. On each side of the centrum is seen a process, the pleurapophysis (πλευρα, a rib), *pl. ap.*, which commonly, as in the ribs and pelvis, enters into the formation of the hæmal arch. Two additional processes are occasionally met with; these are the epapophysis (επι, upon), on the superior, and the hypapophysis (υπω, below), on the inferior aspect of the body. The component parts of a vertebra have been called *autogenous* or *exogenous*, according to their mode of development. The autogenous parts, called also the elements of the vertebra, are such as are developed from independent centres of ossification; the exogenous, called also the processes, are such as grow from previously ossified parts. No definite line can be drawn between them, however, and we may find homologous parts in different regions of the same animal even differently developed. As a general rule, the autogenous parts comprise the centrum, the neurapophyses, and the neural spine, the pleurapophyses, the hæmapophyses, and the hæmal spine; the remaining parts are commonly exogenous.

Typical character of dorsal vertebræ in the horse.

Nearly all the component parts of the typical vertebra may be traced in the accompanying cut of a dorsal segment of a horse. The homologous parts in this specimen are marked by the same characters as in the typical vertebra, so that there is no call for the repetition of their description.

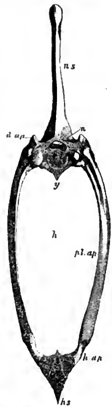

Fig. 62. Thoracic Segment. *c*, centrum; *n*, neural arch; *h*, hæmal arch; *n.s.*, neural spine; *h.s.*, hæmal spine; *d. ap.*, diapophysis; *h. ap.*, hæmapophysis; *y*, hypapophysis; *pl. ap.*, pleurapophysis.

The centrum, it will be observed, corresponds to the body of the vertebra, the neural arch to the spinal canal, and the hæmal arch to the cavity of the thorax; the pleurapophyses are represented by the ribs; the hæmapophyses, by their cartilages of prolongation; the hæmal spine, by the sternum, and so on.

Modifications of type in different regions. In head.

The vertebræ undergo very different grades of development according to their situation; thus the neural arch is most largely developed in the head, the great increase of the nervous matter at this part necessitating a corresponding increase in the capacity of its bony envelope; the hæmal arch attains its greatest development in the dorsal vertebræ, its expansion in this region being for the purpose of enveloping the great vascular and ærating organs. At this part, indeed, we have perhaps the most complete example of a vertebra that our domestic animals supply, since the neural and hæmal arches, and most of the apophyses are considerably developed. In the cervical and lumbar vertebræ the hæmal arch is only represented by various apophyses, while in the coccygeal both arches disappear, the only parts left being the centrum (*c*), with slight projections indicating the positions of the abortive arches.

In dorsal region.

In cervical and lumbar.

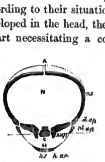

Fig. 63.—(Quain and Sharpey.) Cranial Segment.

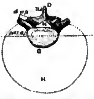

Fig. 64.—(Quain and Sharpey.) Lumbar Segment.

Different parts of a segment, not always anchylosed.

The vertebræ vary likewise in the degree in which the different existing parts of a segment are blended together. Thus, in certain regions, (cervical and lumbar), the existing parts of each segment form a single bone, in others (dorsal) one or more component parts remain separate, and perform the functions of different bones, as is well illustrated in the ribs.

Several segments sometimes joined into one solid mass. In head. In sacrum. Purpose of this.

Still other modifications are to be noticed: thus, in the head, which in reality consists of four vertebral segments, these become blended into a single bony mass, so far at least as the neural arches are concerned, becoming thereby better adapted to the protection of the cerebral mass; in the sacrum also, a number of segments, varying according to the species of animal, are ossified together to form a fixed point to which the hind limbs are attached. The hind limbs are to be considered as appendages of those vertebral segments which enter into the formation of the pelvis, but considerably modified

Fore limbs attached to hæmal arch

to suit them to the purposes of locomotion. The fore limbs again represent prolongations of the hæmal arches of the fourth or occipital vertebral segment, in this case displaced and applied over the lateral parts of the thorax, the better to act as organs of support and motion. The segments composing the fore and hind limbs have undergone considerable modifications, being divided longitudinally and transversely into several pieces, and furnished with joints possessed of various degrees of motion, the better to adapt them to the performance of their allotted functions. There is likewise a remarkable analogy between the fore and hind limbs in their entire structure, the variations being such as to adapt them to the different positions they occupy in the animal economy.

of fourth vertebra.

Correspondence of the fore with the hind limbs.

Consideration of each detached ossific element as separate bone.

In a work like the present, devoted to special anatomy, the homological classification must be partly set aside, to allow the consideration of each bone individually, other terms more commonly employed in special anatomy being at the same time used. A vertebral segment in this restricted sense will comprise simply the body (centrum), with the various projections immoveably connected therewith. The detached parts, such as the constituents of the hæmal arch in the dorsal region, are considered as separate bones, and under separate names.

VERTEBRAL COLUMN.

Vertebral column, a chain of bones.

Runs from, before backward.

Moveable and fixed vertebræ.

The vertebral column or back-bone is a solid flexible chain, composed of a variable number of pieces, and acts as a central column of support to the whole body. In the lower animals it is arranged in an antero-posterior direction, extending throughout the entire length of the body, being limited anteriorly by the head, and posteriorly by the bones of the tail. Like all single bones (not arranged in pairs) the vertebræ are symmetrical, *i. e.*, each side is nearly the exact counterpart of the one opposite. They are divided into moveable and fixed vertebræ, the former comprising all those segments that enjoy a certain amount of motion upon one another, the latter those parts in which two or more segments are ossified together so as to constitute a single bone.

The segments have general, regional, and individual, characters

Taking the vertebræ in the aggregate, we find them possessed of certain common characters by which any segment of the chain may be easily distinguished from any other kind of bone; next we find certain distinctions by which those belonging to particular regions may be referred to their natural situations, thus they are readily divisible into the cervical, the dorsal, lumbar, sacral, and coccygeal;

lastly, we find peculiarities characteristic of the individual segments. These will, accordingly, be noticed separately.

GENERAL CHARACTERS OF A VERTEBRA.

Parts of a vertebra.

A vertebra is an irregularly quadrangular bone, with a central solid part or body, surmounted by an annular part or ring, and possessing articulating, transverse, and spinous processes, besides notches and foramina.

Cylindrical body.

Inferiorly is situated the body, in the form of a somewhat irregular cylinder, having four surfaces, two lateral, a superior, an inferior, and two extremities, an anterior and posterior. The two lateral surfaces being blended with the pedicles, and various processes, do not offer themselves for consideration. The superior surface, which constitutes the floor of the great spinal canal, is tolerably smooth, but has toward its middle a somewhat roughened part, in relief, in the form of two isoceles triangles united by their apices, and presenting their bases to the anterior and posterior extremities respectively. This part (rudimentary epapophysis) is intended for the insertion of the superior common ligament of the vertebræ and meninges of the cord. The lateral, excavated part, has one or two foramina for the passage of nutrient vessels into the bone. The inferior surface is convex, having in its median line a ridge called the inferior spine (hypapophysis). The body is somewhat constricted in its middle, so as to be less bulky than at the extremities. The whole surface, with the exception of the articulating parts, is studded with foramina, chiefly for the passage of veins.

Convex anteriorly.
Convex posteriorly.

The anterior extremity is convex, being more or less prominent, according to the region, while the posterior extremity is furnished with a concavity for articulating with the head of the next bone, but larger than would correspond to the size of the head, the intervening space being filled up by fibro-cartilage.

Ring.

The ring (neural arch) is formed by two strong bony plates, rising from the supero-lateral parts of the body, and uniting in the median line above, enclosing a space which constitutes a segment of the vertebral canal.

Formed of pedicles, laminæ.

These plates are somewhat narrowed at their origin, and to this constricted part, the name of pedicle has been given; the more expanded part, extending on each side from the pedicle to the point of union superiorly, is called the lamina. The inner surface is smooth, to adapt it to the spinal cord. The external surface is irregular, with projections from various parts of its structure. From the point of union of the pedicles and laminæ, at their anterior and posterior borders, start out oblique or articulating processes (zygapophyses), two proceeding forwards, and two backwards, for articulation with corresponding processes on the vertebra in front and behind. These are called the anterior and posterior articulating processes. From either side of the arch, and between the bases of the articulating processes, jut out the transverse processes (diapophyses). At the junction of the two laminæ, the spinous process (neural spine) arises; this, like the transverse process, serves for the attachment of muscles.

and processes.

Articulating processes, start from union of pedicles and laminæ.

The transverse are between the articulating processes.

Spinous process at the union of the laminæ above.

At the anterior and posterior margins of the pedicles are notches, which, when the bones are placed in their natural position, form between every two bones an aperture for the transmission of nerves and blood-vessels. This aperture is called the foramen of conjugation, or intervertebral foramen. The notch on the posterior margin of the pedicle is generally the deepest.

Intervertebral foramen.

In structure, the vertebræ are composed of spongy and compact tissue, the former constituting the mass of the body, which is covered by an extremely thin layer of compact structure. In the part constituting the ring, the latter largely predominates. Its substance is traversed by numerous vascular canals that open upon the surface of the bone.

Structure very spongy.

There are three primary points of ossification in a vertebra, one for the body, and one for each of the laminæ. The former of these is sometimes developed from two lateral centres of ossification.* There are generally five other complimentary points of ossification, one of these is for the cartilage on the summit of the spinous process, one for the extremity of each of the transverse processes, one for the head, and one for the posterior concavity of the body.

Development.

CERVICAL VERTEBRÆ.

The cervical vertebræ are distinguished from those of any other region by their greater size. The body is, in the horse, from 3 to 4 inches long, has a prominent inferior spine, terminated posteriorly by a tubercle; a large head, forming nearly half a spheroid, and a very deep or cotyloid cavity posteriorly. The laminæ are broad, cor-

General characters. Body long.

Large head, deep cavity.

Broad laminæ.

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* Albers, Humphrey, Müller.

responding in this to the length of the bone, and at their union superiorly there is a slight roughened crest or superior spine.

Transverse process bifid or trifid, with a hole at its root.

The transverse processes are large, single, bifid, or trifid, and project downward; when trifid the middle projection turns upward. At their base they are pierced by a foramen for the transmission of the vertebral artery (vertebral foramen.)

Large articulating processes.

The articulating processes are largely developed, the surface for articulation in the anterior being directed upward, inward, and slightly forward, in the posterior outward, downward, and slightly backward. The notches in the pedicles are of great size.*

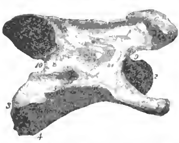

Fig. 65. Cervical Vertebræ. 1, Body; 2, Head; 3, Posterior articular cavity; 4, Inferior spine; 5 5, Transverse processes; 6 6, Oblique articulating processes; 7, Foramen for the vertebral artery. 8 8, Pedicle; 9, Anterior intervertebral notch; 10, Posterior intervertebral notch.

Atlas.

Tubular form.

Individual characters.—The *first cervical vertebra*, called also the *atlas*, from its supporting the head in the human subject, consists of a central annular or tubular part, with two lateral alæ or wings, that greatly increase its transverse diameter. The annular part, which is very large, is not entirely filled up by the spinal cord, it contains also the odontoid process of the dentata, strong ligaments, and a quantity of fat.

Body thin.

The body is represented by a thin bony plate, having on its inferior surface a tubercle or inferior spine.

Anterior articulating surface or cavity.

Its head is replaced by two lateral articular facets, turned upward; these, with two smaller articular facets, corresponding to the articulating processes, which look downward, form two great cavities for the reception of the condyles of the occiput.

Upper surface of the body.

The superior surface of the body, forming the inferior boundary of the medullary canal, has its anterior half roughened for ligamentous insertion, with the exception of two lateral concavities for venous sinuses; the posterior part separated from the former by a transverse ridge, is smooth and transversely concave, forming an articular surface for the odontoid process of the next bone. The laminæ are of considerable breadth, and on their summit bear a prominence with some asperities for the insertion of muscles. The transverse processes are very extended, constituting the alæ; they are flattened from above downward, are situated obliquely on the bone from behind upward and forward, are directed outward, and slightly downward, and have a thickened and tuberous margin. They are each peirced by three foramina, the posterior of which—the largest—corresponds to the vertebral foramen in the other cervical bones. Another near the anterior margin of the process penetrates it from below upward, and communicates by means of a deep canal with the third, which pierces the transverse process and the lamina opening into the

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* The great mobility of the neck requires the modifications just noticed; the large head, the larger cotyloid cavity, and the extensive articulating surfaces on the oblique processes, allow great latitude of motion, while the powerful fibro-cartilaginous, ligamentous, and muscular connexions, are sufficient guarantees of its strength. The large intervertebral foramen obviates any pinching which might otherwise result to the blood-vessels, or the great nervous trunks given off by the cord in this region.

Laminæ broad.

Transverse processes or alæ.

Posterior hole in the ala is the vertebral.

Two anterior holes corresponding to first hole of conjugation.

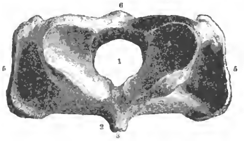

Fig. 66.

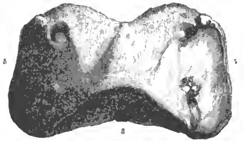

Fig 67.

Fig. 66. Upper view of Atlas. Fig. 67. Front view of Atlas. 1, Ring or spinal foramen; 2, Body; 3, Inferior spine: 4 4, Lateral articular facets. 5 5, Transverse processes or alæ; 6, Superior spine or roughened surface for the ligamentous attachment. On the surface of the alæ, the foramina mentioned in the text are seen.

medullary foramen. These two last correspond to the intervertebral foramen, giving exit to the first pair of spinal nerves, and passage to several blood-vessels. A fourth foramen from the internal part of the ring pierces the lamina, and opens beneath the ala in front of the large posterior foramen. Sometimes a vascular canal traverses the superior surface of the bone from the posterior to the anterior foramina. On each side of the medullary foramen posteriorly is a large articular facet, convex from within outward, corresponding to the posterior articulating process, and continuous with the cavity for the reception of the odontoid process.

A fourth foramen in the lamina.

Postero-lateral articulating facets.

Structure.

The atlas contains less spongy tissue than any other vertebra, since at no part has it any bulk of bony matter.

Development from three centres.

It is developed from three points of ossification, one for the body, and one for each of the tranverse processes and laminæ.

Longest of cervical vertebræ.

Odontoid process.

Lateral articulating processes.

Superior spine bifid.

Transverse process single.

Second foramen of conjugation formed by this bone.

The *second cervical vertebra* is called the *axis*, from its acting as a pivot in rotary motions of the head; also the *dentata*, from its anterior tooth-like projection. It is the longest of the cervical vertebræ. Its small anterior head is resolved into a conical process, the superior surface of which has asperities for the insertion of ligaments, while the inferior is smooth and rounded from side to side, adapting it to work pivot-like in the ring of the atlas. On each side of this process is an articulating facet (zygapophysis) for articulation with the corresponding facets on the atlas. The body of the bone is enlarged posteriorly, where it presents a cotyloid cavity. The superior spine is large, tuberous for muscular attachment, and bifurcated posteriorly, each division running back to become amalgamated with the posterior articulating process. The transverse process is small and single, projecting backward and upward. It is pierced by the vertebral foramen. The second intervertebral foramen is formed by the axis alone, being either entirely surrounded by bone, or completed anteriorly by ligament. At the posterior part of the pedicle a notch contributes to the formation of the third intervertebral foramen.

Structure.

The dentata contains a large quantity of spongy matter, so that, though of great size, it is comparatively light.

Development.

It is formed from five centres of ossification, one for each lamina and its processes, one for the body, one for the odontoid process, and one for the posterior concavity.

Third and posterior vertebræ.

The cervical vertebræ from the third backward progressively decrease in length, and increase in breadth.

The *third*, *fourth*, and *fifth* may be taken as types of the ver-

Differences between the third, fourth, and fifth.

tebræ in this region. Their distinguishing individual characters are:—the inferior spine becomes shorter and more tuberculated in the fourth, and especially in the fifth;—the vertebral foramen gradually increases in size in the same bones;—the anterior and posterior

Fig. 68.

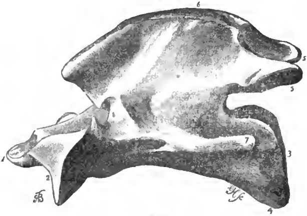

Fig. 69.

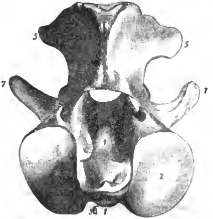

Fig. 68. Side view of Dentata. Fig. 69. Front view of Dentata. 1, Odontoid process; 2, Articular surfaces corresponding to the atlas; 3, Glenoid cavity to articulate with head of third cervical vertebra; 4, Inferior spine; 5 5, Oblique processes; 6, Bifid superior spine; 7 7, Single transverse processes; 8, Anterior intervertebral notch approaching the form of a perfect foramen; 9, Body of dentata.

articulating processes are quite distinct from each other in the third;—in the fourth the posterior half of the intervening space is filled up by a bony ridge, while in the fifth this ridge often unites the two processes, becoming at the same time thick and roughened. In all three the transverse processes are double, and the superior spines are bifurcated posteriorly.

Sixth has long superior spine and bifid transverse process.

The *sixth vertebra* is chiefly remarkable for the increased length of its superior spine;—its trifid transverse processes, and the almost entire obliteration of the inferior spine.

Seventh has facets on its body for the first rib.

Single transverse process with no hole.

In the *seventh* the inferior spine is replaced by some slight asperities. On each side of the cotyloid cavity is an articular facet, for the anterior half of the head of the first rib;—the transverse processes are single, and are not penetrated by foramina;—the spinous process is flattened laterally, and considerably lengthened, becoming assimilated to the character of the first dorsal;—the intervertebral notches are very large for transmitting the great nervous trunks that enter into the formation of the axillary plexus;—lastly, the medullary canal, which is enlarged in the sixth vertebra, is still larger in the seventh.

Mammalian neck has always seven segments.

Segments shorter in the ox.

Atlas has thicker alæ.

Differences.—The number of cervical vertebræ is invariably seven in the mammalia.

Foramina more numerous.

Odontoid process semi-cylindrical.

Spine of axis single.

Transverse processes.

The cervical vertebræ in the *ox* are shorter than in the horse, with more prominent processes. The spinous processes are narrowed, and terminated superiorly by a tubercle. In the first the alæ are thicker and shorter than in the horse, the vertebral foramen is replaced by a notch at the side of the medullary foramen; while the anterior foramina are often divided into four,—two of which open into the medullary canal, and two beneath the alæ. The lateral articulating facets posteriorly are nearly flat. In the *axis* the odontoid process is shortened, and from two lateral elevations has assumed the form of half a hollow cylinder. There is no true vertebral foramen, though sometimes a small substitute exists. The spinous process is narrow, and not bifurcated posteriorly. In the *three vertebræ following*, the superior spines are directed forward, gradually increase in length from before backward, and are sometimes bifid superiorly. The anterior and posterior articulating processes are united by a strong bony lamina. The two projections of the transverse process are in the *third* united by a strong bony ridge, which is partially awanting in the fourth, and more so in the fifth, a tubercle being developed on the middle of the ridge. In the *sixth*, the inferior spine, is wanting. The transverse process is bifid, the inferior prolongation being large, and forming the lateral boundaries of a large hæmal canal, and the superior spine is lengthened. The *seventh* is distinguished from all others by the character of its superior spine, which is closely allied, both in breadth and length, to that of the dorsal vertebræ.

Seventh has very long spine.

In the *sheep* and *goat*, the cervical vertebræ are relatively longer than in the ox, but have no other differential character worthy of notice.

Sheep and goat have longer segments.

The cervical vertebræ of the *pig* are adapted to the digging habits of the animal; they are short and bulky, with large and prominent apophyses, slight convexity of the head, and shallow posterior cavity.

Pig has short segments.

In the atlas the alæ project nearly horizontally. The vertebral foramen (not always present) enters beside the posterior articulating facet, and emerges on the lower surface of the wing at a point immediately behind the anterior foramina. The axis has its odontoid process slightly constricted at its base; its spinous process long, flat, and turned slightly backward, and its transverse process small, and pierced by a large foramen, sometimes divided into three. From the *third* backward there are no inferior spines. The *first four* of these have the transverse processes bifid, the superior part being connected by a bony plate with the oblique articular process, and beneath this plate is a large vertebral foramen; the inferior projection is turned down, and recurved inward. The spinous processes have a forward direction, are terminated superiorly by a tubercle, and increase in length from before backward. The *seventh* has the transverse process single, and also joined to the anterior articulating process by a bony plate, beneath which is the vertebral foramen. The posterior notch is entirely surrounded by bone, and from this a vascular canal runs beneath the transverse process to the notch on the anterior part of the pedicle. Its spinous process is of equal length with those of the dorsal vertebræ.

Atlas has horizontal alæ.

Axis: its odontoid, spinous, and transverse processes.

No inferior spines behind the second.

Spinous processes have a forward direction. Seventh has a vertebral foramen.

In the *dog* and *cat* the cervical vertebræ, in most of their parts, bear a somewhat close relation to those of the horse. Beside their smaller size, they are known by the small size of the head and the posterior concavity; by the greater size of the articulating processes, which are united by a bony plate; by the increased length of the superior spine; and by some individual characters.

The segments in carnivora are like horse's. Small head and shallow cavity. Large articulating and spinous processes.

The *atlas* has no tubercle on the inferior part of the body, and the articular surface for the odontoid process occupies the whole length of its superior surface, becoming continuous with the facets for the condyles of the occiput. The posterior lateral facets are resolved into

Odontoid process extends to the anterior of the atlas.

Alæ of atlas go straight outward.

Odontoid process constricted at its base.

Spinous process prismatical.

Third the largest.

glenoid cavities. The alæ go straight outward and slightly backward, and are each pierced by two foramina—an anterior and a posterior. The former opens into the medullary foramen, and corresponds to the first intervertebral foramen, the latter to the vertebral foramen. On the anterior margin of each is a notch corresponding to the second anterior foramen in the horse. The *axis* has a long, cylindrical odontoid process, having a slight constriction at its base, and a somewhat upward direction. The articulating facets at its side are so prominent as to be true condyles. The slender and undivided superior spine is prolonged anteriorly in the form of a prism, the inferior surface of which articulates with the postero-superior part of the ring of the atlas—in some subjects by a diarthrodial joint. The anterior notches are large and never surrounded by bone. The *third* is the largest cervical vertebræ, and its spinous process is a mere crest. The *fourth, fifth, sixth,* and *seventh* gradually decrease in breadth as well as length; their other peculiarities are very similar to those in the horse. The spinous process in the last is not relatively so prominent as in the other animals mentioned, and the transverse process sometimes contains a foramen.

The cervical vertebræ of the *rabbit* correspond to those of the cat.

DORSAL VERTEBRÆ.

Dorsal vertebræ small: their characters.

Spinous process.

Articulating process.

Transverse process, with a facet.

General characters.—The *dorsal vertebræ*, eighteen in number, are smaller than the cervical. The body is short and prismatical, with a less prominent head than the cervical, and a shallower posterior cavity. It bears four articular facets, one on each side of the head, and of the glenoid cavity, which form, with similar facets on the adjacent bones, articulating cavities for the reception of the heads of the ribs. The laminæ are narrow, and surmounted by an elevated spine, with a backward inclination, flattened from side to side, having a sharp anterior border, one or two grooves posteriorly, and a tubercle upon its summit. The articular processes are reduced to simple facets, two on the anterior and two on the posterior part of the base of the spinous process; the direction of the anterior is upward, forward, and outward; of the posterior, downward, backward, and inward. The transverse processes are single, project obliquely outward and upward, and present on their external surface a smooth facet, for articulation with the tubercle on the corresponding ribs. The notches are smaller than in the cervical region, accommodating themselves to the more limited motions of the back. The posterior notches are the deepest, and are sometimes converted into foramina.

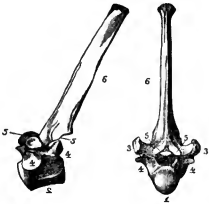

Fig. 70. Fig. 71.

Fig. 70. Side view of Dorsal Vertrebra. Fig. 71. Front view of the same. 1, Body; 2, Inferior spine; 3 3, Transverse processes; 4 4 4 4, Joint surface to articulate with the heads of ribs; 5 5 5 5, Oblique articulating processes; 6 6, Superior spine.

Individual characters.—These are somewhat difficult to give, except in the form of gradual modifications, only appreciable by the comparison of the bones. The transverse diameter of the body is largest in the first, decreases gradually to the tenth, undergoing afterward a slight regular increase to the eighteenth. The vertical diameter undergoes a gradual increase from the first to the last. The head becomes less prominent, and the glenoid cavity shallower from before backward. The facets forming the articular cavities for the head of the rib diminish progressively from before backward. The spinous processes increase rapidly, in length, to the fourth; the fifth and sixth are still higher; from this they diminish progressively to the twelfth, and more slowly to the eighteenth. Their breadth is greatest in the second, diminishes to the eighth, and again increases to the last, four or five of which are scarcely distinguishable, either in length or breadth, from the lumbar. Their obliquity diminishes from the second to the fifteenth; the sixteenth is generally vertical, while the eighteenth, and sometimes the seventeenth, have a slight inclination forward. The tubercle on the spine cannot be said to exist farther

Alteration in transverse diameter.

Changes in vertical diameter.

In hard and glenoid cavity.

In facets for ribs.

In spinous process.

In articulating processes.
Peculiarities of the first;
of the second;
of the last.

forward than the third, or farther backward than the twelfth. The anterior articulating processes from the second to the tenth become more approximated to the median line, but behind this again the opposite is the case. In the two or three last, the anterior facets assume a concave form. The size of the articulating process increases from before backward; that of its articulating facet diminishes. In the three first the facet is concave; in the two or three last it becomes continuous with that on the lateral part of the head. The first dorsal vertebra can at all times be known by its short and pointed spinous process, by the great size and obliquity of its anterior articulating processes, and by the depth of its notches. The same peculiarities exist, but are less marked, in the second. The last has no facets at the sides of its posterior concavity.

Dorsal vertebræ broader in ox.
Spinous and transverse processes.
Intervertebral foramina double.
Modifications of the bodies;
of spinous processes;
of the transverse process.
Facets on articulating process of first;
of the last.
Dorsal vertebræ in sheep and goat.

Differences.—The thirteen dorsal vertebræ of the *ox* are longer and broader than those of the horse. The superior spines are long, very broad, curved posteriorly, and strongly inclined backward; the transverse processes large, bearing articular facets convex from above downward, and the posterior notch is generally completely encircled by bone, forming a foramen behind the base of the transverse process; the second foramen of conjugation is formed by the anterior notch. They decrease in size from the extremities toward the centre, the seventh or central bone being the smallest. From the first to the eleventh there is a regular diminution in the breadth of the spinous processes, especially toward their summits; in the two last, however, it again increases. The first three or four are of equal length; from the fourth the length gradually diminishes. The obliquity increases from the first to the tenth, after which they become again more vertical. In the first four or five dorsal vertebræ, the facet on the transverse process is concave in an antero-posterior direction, though still convex vertically. The facet is absent in the thirteenth, and sometimes also in the twelfth. The articulating facets on the anterior part of the first are large and situated on the superior part of the transverse process in place of the base of the spine. Those in the last two are concavo-convex like in the lumbar. In the *sheep* and *goat* the dorsal vertebræ differ from those of the ox chiefly by their relatively smaller size, by the narrowness of their spinous processes, and by their intervertebral foramina being single like in the horse.

Fourteen dorsal vertebræ in the pig, like those of the ox.

The dorsal vertebræ of the *pig* number fourteen, and bear a striking resemblance to those of the ox in their form, in the character and inclination of their spinous processes, and the formation of a second intervertebral foramen by the enclosure of the posterior notch with a bony plate. They are easily distinguished, however, by the trifid opening of this foramen externally; one of its orifices is behind, one above, and one below the transverse process.

Trifid opening of the hole in the pedicle.

Spinous processes.

Transverse processes.

Articulating processes.

There are few well-marked individual characters. The spinous processes are most oblique from the fourth to the eighth, the ninth is nearly vertical, and the three last are inclined forward. The five last have the transverse process more prominent than in the others, the last resembling the lumbar vertebræ in this respect. The articular facets on the transverse processes of the four last are at their bases, and continuous with those on the body, for the head of the rib. The articulating processes of the five last have their articular facets concavo-convex in a vertical direction, and the anterior processes are tuberculated with the articulating surface internally. In both these respects they correspond to those in the loins.

Dog has thirteen dorsal vertebræ, like horse's.

Peculiarities.

The thirteen dorsal vertebræ of the *dog* possess a strong likeness to those of the horse. The spinous processes are generally narrower and thicker. The first four are of nearly equal length, after which they diminish gradually to the last. Their obliquity increases to the ninth. The tenth is less inclined backward, and ends in a point; the eleventh also approximates to the triangular form, while the two last are broader, short, and perpendicular. The three last have no posterior facets for articulating with the head of the ribs, and their oblique processes are considerably enlarged, the anterior having facets concave from above downward, the posterior convex in the same direction. In the two last a tuberculated elevation arises from the two anterior processes, rendering them in all respects analogous to those of the lumbar vertebræ. In the *cat*, the transverse process is slender, pointed, directed backward, and bears no facet for articulation with the tubercle on the ribs.

In the cat.

The *rabbit* has twelve dorsal vertebræ, very similar to those of the cat.

LUMBAR VERTEBRÆ.

Lumbar vertebræ between the cervical and dorsal in size.

Large, flat, transverse processes.

Short spines.

General characters.—The horse has six (in some subjects five) lumbar vertebræ, intermediate in size between the cervical and dorsal. They are characterised—1st, by enormously developed transverse processes, flattened from above downward, of great length, directed horizontally outward, slightly arched, and terminated by a convex margin; 2nd, by short, quadrilateral, spinous processes, flattened from side to side, terminated superiorly by a rugose crest, and directed

Articulating processes concave in front, convex behind. from below upward and forward; and 3rd, by the character of the articular processes, in size between those of the dorsal and cervical vertebræ; the anterior one is large, surmounted by a tubercle, has its articulating facet concave from side to side, turned inward, slightly forward, and at its inferior part upward, the facet of the posterior is convex from side to side, looking outward, slightly backward, and inferiorly downward.

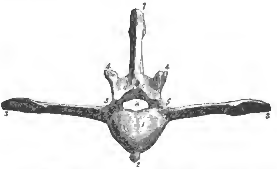

Fig. 72. Lumbar Vertebra. 1, Body; 2, Inferior spine; 3 3, Transverse processes; 4 4, Oblique articulating processes; 5 5, Pedicles, 6 6, Laminæ; 7, Superior spine; 8, Spinal foramen.

Modifications of the body, and of the transverse processes. *Individual characters.*—These exist chiefly in the body and transverse processes. The body gradually decreases in its vertical, and increases in its lateral diameter, from before backward. The transverse processes increase in length from the first to the fourth, from which to the last they regularly diminish; the first two have a slightly backward inclination, the third proceeds nearly straight outwards, while the last three are directed slightly forward; those of the fifth and sixth have on their corresponding margins oval facets by which they articulate, and by which they frequently become ossified together; those of the fourth and fifth often articulate by similar facets on their corresponding margins on one or both sides; those of the sixth have like facets on their posterior margins for articulation with the transverse processes of the sacrum.*

Facets on transverse processes of the two last.

Differences.—The *ass*, and frequently the *mule*, has only five lumbar vertebræ.

Ox has six lumbar vertebræ. The *ox* has six lumbar vertebræ, larger than those of the horse, especially in their length and breadth, and the size of their transverse processes. These last are of great length, increasing gradually to the fourth, the fifth is of nearly equal size, and the last considerably diminished. With the exception of the first and second, they are arched considerably, with a downward inclination at their free extremity, have irregular borders, the anterior concave, the posterior convex, and rarely have articulating facets between the fifth and sixth nor between the last-named and the sacrum. The notches are remarkably deep, the posterior being, in the three first vertebræ, completely isolated by a small ligament and sometimes in the first by bone, constituting two foramina, as in the dorsal region. In the last the spinal canal is nearly doubled in the length of its transverse diameter, and diminished considerably vertically.

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* The obvious use of these articulations is to increase the strength and solidity of the parts.

Transverse processes.

Notches in first, divided by a ligament.

In the *goat* the chief difference is the more downward inclination of the transverse processes.

Goat.

In the *sheep* seven lumbar vertebræ are not unfrequent, and the transverse processes of these are turned up at their extremities.

Sheep.

The *pig* has six lumbar vertebræ. Sometimes the anterior sacral is detached, giving the appearance of seven.* They correspond in most respects to those of the ox, but differ in having the posterior notch formed into a foramen, with three external orifices, like in the dorsal region.

Pig has six.

Notches like in the dorsal region.

The *dog* and *cat* possess seven lumbar vertebræ, of great relative size and strength. Their transverse processes are long, directed downward and forward; their length increases from the first to the last, their breadth to the fourth, in some subjects, in others as far as the last. The notches are very large, and by the side of the posterior is a small projection becoming gradually less from the first backward, and exactly representing the transverse process of the dorsal region (diapophysis). The tubercle on the anterior articulating process is drawn out in a direction upward, forward, and outward. The spinous processes have a remarkable inclination forward, their breadth at their superior extremity diminishes progressively in the three last, so that two or more often terminate in a point; it frequently increases, however, from the first to the fourth.

Carnivora have seven lumbar segments.

Transverse processes get longer to the last.

Articulating process.

Spines.

The *rabbit* has seven lumbar vertebræ, similar to those of the cat, but stronger. The only other marked property is the presence of an inferior spine.

Rabbit like in the cat.

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* Chauveau.

SACRUM.

Sacrum is formed of five segments.

Is triangular.

There are, in reality, five sacral vertebræ, but as these are united together by osseous union, they are more conveniently considered as a single bone. This bone, called the *sacrum*, is in the form of an isoceles triangle, having its base presented forward, articulating with the last lumbar vertebræ, its apex backward, articulating with the first bone of the coccyx; while on its supero-lateral parts it articulates with the ossa innominata, between which it is inserted like a wedge, so as to form the superior wall of the pelvis. It is flattened from above downwards, and is slightly arched upward in an antero-posterior direction. It presents two surfaces, two lateral borders, a base, an apex, and a central canal (spinal canal).

Fig. 73.

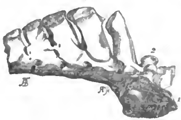

Fig. 74.

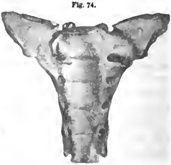

Fig. 73. Side view of Sacrum, indicating the five superior spines; the superior foramina; the transverse processes or alæ at 1, the oblique processes at 2. Fig. 74. View of Inferior Surface of Sacrum, indicating median depression, and four pairs of foramina, wings, and articulatory surfaces.

Superior surface has five processes.

Superior sacral foramina.

The *superior surface* has five projections in the median line (superior spines), distinct from each other at their apices, unless in the two last, having a backward inclination, gradually diminishing in length from the second backward, and in all except the first terminated superiorly by a tubercle. On each side of the sacral spine is a groove containing four foramina (superior sacral foramina), giving passage to blood-vessels and the superior branches of the sacral nerves. This groove has on each side a row of tubercles, the upper corresponding to the articulating, the lower to the transverse processes of the lumbar vertebræ. The inferior or pelvic surface is smooth, concave, shows depressions corresponding to the original divisions of the bones, and

Inferior sacral foramina.

laterally has four foramina on each side (inferior sacral), which unite in the substance of the bone with the superior sacral foramina, and penetrate the spinal canal, forming the true intervertebral holes.

Lateral margins, carry a facet on either side.

The *lateral borders* are concave and tuberculated, giving attachment to the sacro-sciatic ligaments and several muscles. The concave form of the margins is chiefly dependent on the lateral prolongation of those parts corresponding to the transverse processes of the two or three first vertebral segments, to which projections the name of branches have been given. Each of these bears at the point corresponding to the two first segments an irregular surface for articulation with the ossa innominata. This surface looks obliquely upward, backward, and outward, and presents inferiorly a small articular facet, surmounted by asperities for the insertion of the ileo-sacral ligaments.

Base. Head. Spinal canal. Two antero-lateral oval facets.

The *base*, by its breadth and the surmounting neural arch, takes on the character, to some extent, of the base of a pyramid, of which the whole sacrum forms no inapt representation. It presents in the median line a transversely oval and slightly convex head for articulation with the body of the last lumbar vertebra; immediately above this is the orifice of the spinal canal, having on each side an articulating process corresponding to that on the last lumbar vertebra, and a notch entering into the formation of the intervertebral foramen. Laterally are two transversely oval diarthrodial surfaces articulating with those on the posterior of the transverse processes of the last lumbar vertebra.

Apex is truncated.

The *apex*, turned posteriorly thick and truncated, presents an oval surface (the body of the last sacral vertebra) for articulation with the first bone of the tail, and laterally two notches to form with similar notches on the bone just named a foramen of conjugation.

Spinal canal.

The *spinal canal* in the sacrum is regularly triangular, and its breadth diminishes from before backward.

Development.

Each of the five pieces of the sacrum has the same points of ossification, and follows the same mode of development as the vertebræ generally.

Ox's sacrum. Spines form a ridge.

Differences.—The *ox*, like the horse, has the sacrum composed of five vertebral segments joined into a single bone; it is larger, however, and more curved. Its spinous processes are ossified together up to their summits, which are thick and tuberous. At their base is a ridge corresponding to the articulating processes; the superior foramina are somewhat irregular in size, while the inferior are gene-

Facets for pelvic bones are more vertical.
No facets for transverse process of the lumbar vertebræ.

rally larger than in the horse; in both cases the same number exist as in the latter animal. The lateral plates corresponding to the transverse processes of the two first vertebral segments project suddenly outward, and are more turned down posteriorly; their surface for articulation with the ilium is more vertical, and the diarthrodial facet is better developed. This anterior border has no facets for articulation with the transverse processes of the last lumbar vertebra.

Sheep has only four segments.

In the *sheep* and *goat* there exist only four vertebral segments in the sacrum. There are consequently only three lateral foramina on each side above and below; in all other respects they bear a close resemblance to those of the ox.

The pig has four segments.
No spines.

The sacrum of the *pig* is composed of four pieces, which are late in being ossified together, so that it is sometimes difficult to tell where the sacrum ends and the coccyx begins; the most distinguishing characteristic would seem to be the absence of articular processes in the sacral, and their presence in several of the first coccygeal. It has no supra-spinous process, and the laminæ in each segment are not ossified to those in front and behind, so that spaces are left between the segments leading into the spinal canal. On the inferior surface of the bone are a series of transverse ridges.

Carnivora have three segments.
Facet for ilium looks outward.

The sacrum of the *dog* and *cat* is very much arched, turning sharply upward from the horizontal line of the lumbar vertebræ. It is formed of three segments, becoming early ossified together, and has on each side four foramina, two above and two below. The surface for articulation with the ilium is very extensive, nearly vertical, and looks directly outward. It bears at its lower margin a diarthrodial facet of considerable size. The parts corresponding to the posterior, articular, and transverse processes are well developed, giving the bone a somewhat quadrangular form. The first caudal is frequently anchylosed to the sacrum.

Rabbit.

In the *rabbit* the sacrum is made up of four segments, the superior spines of which are not united by ossification.

COCCYGEAL VERTEBRÆ.

Bones of the tail.
First three have a spinal canal.
Next three have rudimentary laminæ.

The bones forming the coccyx in the horse vary in number from twelve to eighteen. The three first possess most of the characters of other vertebræ, having a body and neural arch, with spinous and transverse processes, the latter having a backward and outward direction; in the fourth the laminæ do not unite superiorly, the neural arch is consequently incomplete; in the seventh the laminæ are represented by the merest crests only, which are entirely absent in the four or five last. The transverse processes diminish in the same ratio, so that from the sixth or seventh backward, there exists the body only, constricted in the middle with four minute prominences at either extremity, two superior and two inferior, and corresponding to the articular and transverse processes, giving to the end of the bone a quadrilateral form. The inferior surface of the body is flat in some of the first, but the bone soon becomes perfectly cylindrical. Along its entire course the coccyx gives insertion to four sets of muscles, namely, on its superior, inferior, and two lateral surfaces. Unlike the vertebræ in every other region, both the anterior and posterior extremity of the body are convex, a remarkable provision for securing the mobility of the tail. Mobility is further increased by the large amount of intervertebral fibro-cartilage.

Seventh has body only.

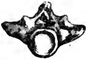

Fig. 75.—First coccygeal bone of the horse, showing the transverse processes and peculiar form of the body and spinal foramen.

Both ends are convex.

These imperfect vertebræ contain a great amount of cancellated tissue, by which an eminent degree of lightness is secured.

Structure.

They are developed from three centres of ossification—one for the body, one for its anterior, and one for its posterior epiphyses; in the case of the two first, however, there are two additional for the laminæ.

Development.

In old horses the first is very frequently ossified to the sacrum.

Differences.—The coccygeal vertebræ in the ox, from sixteen to eighteen have all the prominences better developed than in the horse. Rudimentary articulating processes exist in the four or five first. The bones accordingly appear broader, and are at the same time longer than in the horse.

Ox has sixteen to eighteen.

The *sheep* and *goat* have from ten to fifteen coccygeal bones, similar to those of the ox, and have a neural arch in the first five.

Sheep and goat have ten to fifteen.

The *pig* has from fourteen to twenty bones of the tail, closely corresponding to those of the ox, but remarkable for having true articulating processes in the most anterior. The spinal canal is continued as far as the third.

In pig are like in the ox.

In the *dog* and *cat* the number varies from six to eighteen. They are more tuberculated than in other animals, and in the four or five first, have all the characters of true vertebræ, with well-defined neural arch, and large articulating and transverse processes, the latter projecting backward and outward.

Carnivora have the processes better marked.

THE VERTEBRAL COLUMN AS A WHOLE.

Has four surfaces, a canal, and curves.

The vertebral column, as we have considered it (excluding, in this case, the head), is, when connected together, naturally an extensive bony chain, bearing the head on its anterior extremity, and terminating posteriorly in a point. It presents for consideration four surfaces, viz., superior, inferior, and two lateral, and a central canal, together with several curves of different sizes.

Ridge of spines on the superior surface.

Their modifications.

The *superior surface* presents on its median line a series of projections (superior spines), which act as levers for muscular attachment. These are extremely short in the cervical region, very long and inclined backward on the dorsal region, shorter, and having a forward inclination in the lumbar, again turned slightly backward in the sacral, and almost entirely wanting in the coccygeal. Laterally on each side is a row of tubercles for muscular insertion, represented in the cervical region by the articular, in the dorsal by the transverse processes. Between these and the spines is an excavation, in which lie the extensor muscles of the back. In the intervals between the spines are open spaces leading into the superior part of the spinal canal, and most marked in the cervical region.

Two lateral ridges, caused by articular and transverse processes.

Inferior surfaces.

The *inferior surface* is widest in the neck, gets narrower in the dorsal region, again enlarges somewhat in the lumbo-sacral, and becomes very narrow in the coccygeal. It bears a number of transverse eminences, corresponding to the points of union of the individual segments; these, with depressions, representing the bodies of the bones, give this surface a moniliform appearance. Along the median line is a crest, most marked in the cervical region, by which it is divided into two lateral parts.

Lateral surfaces, present processes.

Notches and facets.

On each *lateral surface* of the column is a line of levers, formed by the transverse processes, modified, as we have already seen, in the sacral region for articulation with the innominate bones. Thirty-six foramina of conjugation, corresponding in size to the bulk of the nervous trunks, by which they are traversed, and to the more or less extensive mobility of the parts; and in the dorsal region, eighteen intervertebral facets for the reception of the heads of the ribs.

Spinal canal.

Its size.

The *spinal canal* has seventy-two lateral foraminæ for the passage of the thirty-six pairs of spinal nerves. It varies in size at different points: thus it is largest in the atlas, greatly reduced in the axis, increases gradually, more especially in its transverse diameter, to the end of the cervical region; after the first dorsal it again diminishes to the ninth, gradually increases again, especially in its vertical diameter, to the last lumbar, from which again it progressively diminishes, and is completely obliterated about the fourth or fifth coccygeal. In the cervical region the transverse diameter is the largest, and in the lumbar, the vertical, while in the dorsal, at the middle of which, it attains its smallest diameter, it is nearly circular. It does not enlarge in constant ratio simply with the increased bulk of the spinal cord, which it encloses. Its great dimensions in the axis far exceeds the size of the medulla oblongata; it is filled up here, however, by fat and ligaments. The cervico-dorsal enlargement corresponds to the great increase of the spinal cord, where it gives off the large roots for the formation of the axillary plexus; the lumbo-sacral dilatation corresponds in the same way to the bulging of the cord in that part where the sacral plexus arises.

Not always equally filled by the spinal cord.

Curves

The vertebral column as a whole, is arranged in an antero-posterior direction, but it does not proceed with the regularity of a mathematical line. On the contrary, it is furnished with various curves of different sizes along its course. In the anterior part of the neck, we find a slight curve with its convexity turned upward; at the posterior, cervical, and anterior dorsal region, is a great curve with its convexity downward, so that the cervico-dorsal region presents two curves, together, formed like the letter S; the posterior dorsal and the lumbar regions are nearly straight, while a third curve is formed by the sacrum and the upper part of the coccyx, with its convexity like in the case of the first cervical curve turned upward, and its concavity forming the superior wall of the pelvis. The caudal region is so free as to admit of great variations in position, though in its quiescent state it forms a continuation of the sacral curve. These curves are evidently intended to diffuse the effects of concussion, and to obviate the injuries which might result in the case of a straight and less flexible pillar.

Use of curves.

Mobility.

If we except the coccyx, the cervical region is possessed of the greatest amount of mobility. The dorsal region is well nigh fixed, having very little mobility either vertically or laterally. The lumbar has more vertical motion, but the large transverse processes prevent any extent of lateral motion; in the last, the articulations on these processes fix this bone completely in this respect. This fixity of the last lumbar bones, and the whole of the sacral, adapts them admirably for the reception of impulses from the hinder extremities, and for conveying them to the body at large.

BONES OF THE SKULL.

The segments of the skull.

The skull, considered in its relation to the entire bony framework, is, according to the law of homology, composed of four vertebral segments, viz., occipital, parietal, frontal, and nasal. The three first mentioned enter into the formation of the cranium; the last, of the face only.

Has a pyramidal form.

Composed of twenty eight bones.

Considered as a whole, it is a long, quadrangular, bony pyramid, truncated at its summit, with its base turned upward and articulating with the atlas, its apex inferiorly and free. It is composed, in the very young animal, of twenty-eight bones; but all these, with the single exception of the lower jaw, become ossified together in the fully developed subject.

Divided into cranium and face. The former is formed of eight bones. The latter contains twenty bones.

The skull is divided into two parts, the cranium and face. The former including eight bones, of which four are single—the occipital, frontal, sphenoid, and ethmoid, while four exist in pairs, the parietal and the temporal. The face is formed of twenty bones, nine of which are in pairs—the superior and anterior maxillary, nasal, palatine, pterygoid, lacrymal, malar, snperior and inferior turbinated bones; the single bones are the vomer and the inferior maxillary bones, the last forming the whole of the lower jaw.

Teeth belong to the splanchnoskeleton.

The small bones of the ear and the teeth belong to special organs, and are not true parts of the vertebrate skeleton; they cannot, therefore, be properly enumerated at present.

The position of the head varies much in the living animal; but for the convenience of anatomical description we shall consider it placed horizontally.

I.—BONES OF THE CRANIUM.

OCCIPITAL BONE.

Occipital closes the cranium posteriorly.

This is an irregular bone, situated in the posterior part of the cranium. It forms the whole posterior wall of the cranial cavity, and is bent at right angles superiorly and inferiorly, so as to project some distance on the dorsal and ventral surfaces. It presents, for consideration, two surfaces, external and internal, and a circumference divided by four salient angles into four borders, two of which are supero-lateral and two infero-lateral.

External surface.

Occipital crest.

Foramen magnum

Mastoid crests

The *external surface* presents:—1st. In the median line, commencing on its dorsal aspect, (*a*) a crest extending along its whole dorsal surface; this crest forms the common origin of the diverging parietal ridges to be hereafter noticed, limits the temporal fossæ internally, and affords attachment to the temporal and tempero-auricular muscles; (*b*) a bold, projecting, transverse crest (occipital crest), forming the highest point of the head (poll), and giving attachment to the levator humeri and complexus major; (*c*) below the last, a projection (cervical tuberosity), often studded with spicula for the insertion of the ligamentum nuchæ; (*d*) exactly on the ventral bend of the bone, a large vertically oval aperture (foramen magnum) for the transmission of the spinal cord, with its meninges and the spinal accessory nerve; (*e*) on the ventre is the basilar process, extending forward to join the body of the sphenoid and rounded form side by side, with a slight median depression. 2nd. Laterally, (*a*) two sharp ridges (mastoid crests) forming the continuation of the occipital crest on each side; they proceed downward, outward, and forward, pass the mastoid processes, and become continuous with the zygomatic processes and the mastoid crest of the temporal bone; (*b*) two roughened lines leading from the transverse crest nearly vertically downward, and terminating in the styloid processes; these give attachment to the oblique muscles of the head; (*c*) immediately behind these two concavities for the insertion of the recti capitis postici; (*d*) on each side of

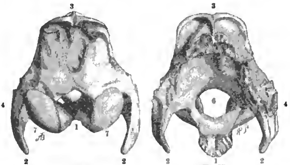

Fig. 76. Fig. 77.

Fig. 76. Back view of Occiput. Fig. 77. Front view of Occiput. 1 1, Basilar processes; 2 2 2 2, Styloid processes; 3 3, Crest. 4 4 4 4, Mastoid crests; 5, Cervical protruberance; 6, Foramen magnum; 7 7, Condyles to articulate with the atlas.

Two condyles. Styloid processes. Condyloid foramina.

the foramen magnum a large condyle, doubly convex, its upper and lower surfaces separated by a sharp transverse margin, and the whole destined to articulate with the diarthrodial cavities on the front of the atlas; (*e*) outside these the styloid processes, flattened from side to side, projecting downward, turned inward at their extremity, and terminated by a small tubercle; (*f*) between the condyles and these processes, fossæ (condyloid fossæ); and (*g*) at the front of each fossa a foramen (condyloid foramen) for the passage of the lingual nerve, a small venous and sometimes an arterial trunk; this foramen is sometimes double.

Internal aspect, has anteriorly the ossific tentorium; posteriorly the foramen magnum.

The *internal surface* of the bone is much less extensive, and bears little relation to its external in form. Superiorly it is divided into an anterior and posterior part by two obliquely transverse diverging lines; the anterior is again divided into three concavities, a central and two lateral, for the reception of the corresponding lobes of the cerebellum; the posterior is concave, and adapted to the medulla oblongata and its meninges. Anteriorly, in the median line, is the ossific tentorium (occipital protuberance of man); it is a prominent plate, flattened from before backward, convex anteriorly, concave posteriorly, pierced at its base by two foramina, which form the orifices of the two parieto-temporal canals. There are two lateral ridges formed by the posterior margins of the parietal, and the anterior of the petrous temporal bones, giving support to the tentorium, a transverse fold of dura mater, dividing the cerebrum from the cerebellum, and enveloping the lateral sinuses. Infero-posteriorly is the internal opening of the foramen magnum. Inferiorly is the superior surface of the basilar process, slightly excavated for the reception of the medulla oblongata. Laterally are the internal apertures of the condyloid foramina.

Circumference. Lacerated foramen.

The antero-lateral borders are thick, serrated anteriorly, smooth posteriorly; the infero-lateral (those of the basilar process) are sharp, forming the internal border of a large foramen (foramen lacerum basis cranii), which is divided in the fresh state by a ligament into a superior and an inferior portion. The free end of the basilar process is roughened to unite with the sphenoid.

Articulations.

The occipital *articulates* with eight bones, viz., with two parietal and temporal by its supero-anterior borders, with the sphenoid by its basilar process, and with the atlas by its condyles.

Structure.

The cancellated tissue predominates, covered by a thin compact layer, internally and externally.

Development.

It is *developed* from five points of ossification, one for the superior plate of the bone, one for each of the condyles and styloid processes, and containing the condyloid foramen, and one for the basilar process. These unite around the foramen magnum, but remain separate for a considerable time after birth. The fifth centre of ossification is in the dorsal angle, causing the development at this part of a separate bone, called os triquetrum.* It is this bone that bears on its internal surface the ossific tentorium.

Ruminants have no occipital crest.

Differences.—In the *ox*, the occipital bone has no superior bend, nor does it form that part which, on superficial observation, might be taken to correspond with the poll of the horse. The cervical tuberosity is blunt, and from its sides start two roughened lines, convex inferiorly, corresponding to the lateral crests in the horse. The foramen magnum is transversely oval. The basilar process, shorter and more bulky than in the horse, is fluted on its inferior surface. The styloid processes are short, thick, and turned inward, the inferior face of each condyle is concavo-convex from before backward, and there are two condyloid foramina,—the inferior being the true condyloid foramen, the superior dividing into two channels, one of which, turning backward, opens on the internal surface of the bone; the other, going forward, traverses the temporal bone, and opens on the internal surface of the parietal. The foramen lacerum is divided by a transverse, bony plate, into a superior and inferior portion, which correspond to the two lacerated foramina in man. In the ox no ossific tentorium exists.

Two condyloid foramina.

Lacerated hole divided by bone.

Sheep and goat.

In the *sheep* and *goat*, most of the peculiarities of the ox are retained. The curved crests, replacing the occipital crest, are well-marked, forming the most salient point on the dorsal surface of the cranium. In the goat especially, and in the stag, this is the case, the head in these animals approaching the horse's in form.

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* The ossa triquetra, or Wormian bones, as they have been called, after a learned Danish professor (Wormius), who gave the first detailed description of them, are occasionally found in the sutures of the cranium, but more commonly in this, the lambdoidal suture, than in any other. The cause of their development would seem to be the late stage at which the bony deposit advances to the margins of the bones, and they may occur, as in the present instance, during the natural development of the cranium, or, as occurs in some forms of disease, from an abnormal retardation or arrestment of the progress of ossification. Of this latter cause we have a well-marked example in hydrocephalus, wherein the enormous expansion of the cranial cavity prevents the extension of ossific deposit to the margins of the bones until very late; in such a case, the membrane existing between the various centres of deposit has bony matter thrown out at various parts, and numerous centres of ossification are thus developed, the resulting bones becoming united to one another in the usual manner. These are much more common in the healthy condition in man than in the lower animals, the distance from the centres of ossification to the margins of the bones being much greater.

Forms an occipital crest in the pig.

In the *pig* the occipital bone forms the superior crest, but is not prolonged on the dorsal aspect, being joined by the parietal immediately in front of the crest. It has no cervical tuberosity, its posterior surface is, on the contrary, excavated. The basilar process is broad and thin, having in its median line, inferiorly, a crest with two lateral concavities. The styloid processes are very long, rounded, and turned forward at their extremities, and, like in the horse there exists only one condyloid foramen on each side. No ossific tentorium is present.

Long styloid process.

No ossific tentorium.

Dog and cat.

In the *carnivora* the occipital crest is well-developed; the cervical tuberosity variable, sometimes absent; the styloid processes short; the foramen lacerum divided into two by bone; the basilar process large, long, and thick, having laterally a groove, which, with a similar groove on the temporal, forms a venous canal, communicating in front with the depression for the cavernous sinus on the sphenoid bone, and opening posteriorly into the posterior lacerated foramen. The angle on the dorsal surface projects a considerable distance between the parietals in the median line, forming a part of the superior wall of the cranium.

Large ossific tentorium in the cat.

In the *cat* the ossific tentorium is very prominent, and the lateral ridges largely developed, so as to form a great transverse plate, representing the tentorium in other animals.

PARIETAL BONES.

Position.

The *parietal bones* (a pair), are situated in front of the occipital, on the dorsal aspect of the cranium, covering the greater part of this cavity. They are large, square, and flat, convex externally, concave internally, and each presents two surfaces and four borders.

Form.

To put the bone in the proper position, place the bevelled border inferiorly, its most acute angle antero-superiorly, and its convex surface externally.

Parietal crest.

The *external surface* presents a line (parietal crest), diverging from the middle of its superior border, and running forward and outward, to become continuous with the orbital process of the frontal. By this crest the surface is divided into two parts, the antero-superior uniting with a similar part on the other parietal to form a median, triangular, sub-cutaneous space, continuous with the superior aspect of the frontal; the postero-inferior traversed by several canals, and pierced by foramina, forms part of the temporal fossa, and lodges the temporal muscle.

Forms part of the temporal fossa.

The *internal* or *encephalic surface* is concave, marked by digitated impressions, and permeated by branching vascular canals, corresponding to the divisions of the median meningeal artery.

Internal aspect has impressions and grooves.

The *anterior border* is concave, thick, and dentated; the *posterior* thick, slightly dentated, and notched; the *superior* thick and serrated, having a slight elevation along its inner aspect, which, with that of the opposite bone, forms a ridge—sometimes a canal with two rough and prominent margins—for the support of the falx cerebri, and the longitudinal sinus; the *inferior margin* has, near its middle, an angle dividing it into two parts, the anterior thin and bevelled, to articulate with the squamous temporal, the posterior smooth, and bearing a groove, which contributes to the formation of the parieto-temporal canal.

Borders.

Inferior forms part of the parieto-temporal canal.

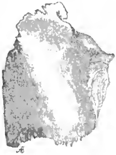

Fig. 78. Parietal Bone.

It articulates anteriorly with the frontal bone, posteriorly with the occipital, internally with its fellow, and externally with the temporal bones.

Articulations.

This bone contains a large amount of compact tissue, the cancellated existing at its superior and posterior parts alone. Each bone is formed from a single centre of ossification, the pair becoming united about the second or third year. In the very young animal there exist no parietal crests nor temporal fossæ.

Structure.

Development.

Differences.—In the *ox* the parietal is a single bone, situated at the posterior part of the head, below the frontal, which in this animal forms the summit of the skull. It is only a narrow plate, elongated transversely, bent laterally at acute angles, so as to form part of the crests leading to the zygomatic processes, and extending forward in the temporal fossæ, to join the wings of the sphenoid. On its posterior part are some asperities for the insertion of the ligamentum nuchæ and several muscles. Internally it has scarcely any elevation in the median line, and it contains no parieto-temporal groove. It is developed from three centres of ossification, a central and two lateral,

In the ox is a narrow plate.

Development

and becomes early ossified to the occipital, so that the existence of a parietal in the ox has been doubted.

Larger in the sheep and goat. In the *sheep* and *goat* it is not unlike that of the ox, but is situated in front of the superior angle of the head, is larger, forming a considerable part of the walls of the cranium, and aids in forming a parieto-temporal canal.

Larger still in the pig. In the *pig* the parietal bones are large and thick. Laterally, each has a prominent parietal crest, which does not unite posteriorly, but becomes continuous with the mastoid crest. The pair form a great part of the superior and lateral walls of the cranium, and are developed from two centres of ossification only.

The dog has the parietal bulging laterally. In the *dog* the parietal crest is very salient, and the lateral convexity of the bones (parietal protuberance) is better marked than in the other domestic animals. It contributes to the formation of a parieto-temporal canal, which opens along with its fellow at the median line. The bones are developed from two lateral centres of ossification.

Cat. In the *cat* there are no parietal crests; the tentorium is entirely resolved into a bony plate, by which, accordingly, the cerebrum is separated from the cerebellum.

FRONTAL.

Position. The *frontal* bone is situated in front of the parietal, and behind the nasal bones, occupying that part of the dorsum of the skull corresponding to the union of the cranium and face, and extending some distance on both these regions. It is a flat bone, presenting two surfaces, external and internal, and four borders, anterior, posterior, and two lateral.

Form.

External surface. The bone is bent laterally at acute angles, so as to divide the external surface into three parts—a median and two lateral. The first of these—flat, quadrilateral, and nearly lozenge-shaped—is immediately subcutaneous, and forms that part of the face known as the forehead. From each side of this flattened surface starts out a process (supra-orbital), dividing each lateral part of the surface into two,—a posterior, entering into the formation of the temporal fossa, and an anterior, forming a great part of the orbit. The supra-orbital process is arched outward, enlarged at its extremity, and abuts on the zygomatic arch. It is concave, anteriorly and posteriorly; rounded, and slightly rugose externally, where it gives attachment to the orbicularis palpebrarum; smooth and concave internally, for the reception of the lacrymal gland, and to form the posterior

Anterior aspect.

Supra-orbital process.

Supra-orbital foramen. Lateral surfaces.

wall of the orbit. Its root is perforated by a foramen (supra-orbital) for the transmission of a cutaneous branch of the fifth pair of nerves. Each lateral surface is smooth and concave, the greater part going to form the internal wall of the orbit. Immediately beneath the internal opening of the supra-orbital foramen, are several small foramina for the transmission of small nutrient vessels to the bone; anteriorly to these we find a depression, corresponding to the bend of the superior oblique muscle of the eye, as it plays through its fibrous pulley.

Internal aspect.

The *internal surface* of the frontal is concave, with a transverse projection, which divides it into a cranial and a facial portion.

Cranial portion.

1st. The *cranial portion* is marked by numerous *impressiones digitatæ* for the reception of the convolutions of the brain. It has on its median line a slight crest, or a canal with prominent margins, continuous with that on the parietals, uniting anteriorly with the *crista galli*, and destined for the support of the *falx cerebri*. Laterally, it shows on each side a narrow slit, into which is mortised part of the wing of the sphenoid. 2nd. The *facial portion* is united on the median line to the vertical plate of the ethmoid; laterally is a smooth space, forming the dorsal boundary of the superior nasal chambers; while more laterally are two large apertures opening into two large irregular cavities (frontal sinuses), between the internal and external plates of the bone.

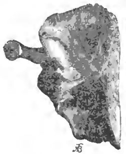

Fig. 79.

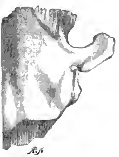

Fig. 80.

Fig. 79. Internal aspect of one-half Frontal Bone. The upper concavity forms part of the cranial cavity, and the lower the frontal sinuses. Fig. 80. External aspect of the same, showing the orbital process, and supra-orbital foramen.

Median crest. Mortice for the wing of the sphenoid. Facial part.

Borders.

The *posterior border* is thick at its median part, and denticulated for articulation with the parietal; laterally it is thin and squamous, to unite with the temporal, and is marked by a groove, which, with a similar groove on the temporal bone, forms a long but very minute canal which proceeds in a backward direction, and opens in the lateral part of the cranium. The *anterior border* is thickest at its central part, where it sends an acute prolongation between the nasal bones; at its extreme lateral part, where it articulates with the lacrymal, it is much thinner, and in both cases is denticulated and slightly squamous. The *lateral borders* are much smaller than the others, and each bears two notches,—a posterior large one for the reception of one of the alæ of the sphenoid, and an anterior, very much smaller, smooth, and with a similar notch on the sphenoid, forming the internal orbital foramen, for the passage of a twig from the ophthalmic division of the fifth cranial nerves.

Articulations.

The *frontal* articulates by its posterior border with the two parietal and two temporal bones; anteriorly, with the nasal, lacrymal, superior maxillary, and palatine; and laterally, with the sphenoid and ethmoid.

Structure.

In the median line posteriorly the bone contains a certain amount of cancellated structure; inferiorly it consists of two compact plates enclosing the frontal sinuses, while laterally a single thin compact plate alone exists.

Development.

The bone is *developed* from two lateral centres of ossification, which are slow to unite, being sometimes imperfectly joined in the median line, even at an advanced age. In the very young colt the lateral salient angles behind the orbits are not well marked, the bone showing a regular convexity at this part. In the young fœtus, again, the facial part of the bone, or of its matrix, is solid; in the fourth month of intra-uterine life absorption commences, and progresses until nearly all the spongy tissue between the compact walls is removed, the internal plate even being considerably attenuated. The sinuses thus formed enlarge with age, but generally remain throughout life separated by a vertical partition.

Formation of the sinuses.

Frontal of the ox.

Differences.—In the *ox* the frontal bone is enormously developed, forming the ridge on the summit of the head and more than half the dorsal surface of the skull. It is of great thickness, to obviate injury from the shocks sustained while using this part as a weapon of offence. It is further distinguished by the following:—1st. From the lateral parts of the frontal ridge project two conical branches of variable size and curvature for the support of the horns. These are rugose, showing numerous longitudinal vascular canals, and are ex-

Two lateral processes support the horns.

tensively perforated for the passage of vessels. 2nd. The supra-orbital foramina (often double on each side) are situated behind the supra-orbital process, pass through a greater mass of bone, are bent in their course, and on the dorsal surface open into a longitudinal canal extending from near the root of the branches to the union of the bones with the lacrymals. 3rd. The orbital process is short, the inferior part of the arch being formed by the malar bones. 4th. The lateral divisions of the external surface are separated from its middle by very acute bends, and the temporal fossæ are very deep. 5th. The internal orbital foramen is entirely formed by the lateral plate of the bone. 6th. The anterior border is deeply notched for the reception of the nasal bones. It does not articulate with the temporal or palatine.

Double supra-orbital foramen.

Opens into vascular canal.

Short orbital processes.

Deep temporal fossæ.

Large frontal sinus.

The two plates of the bone are separated by a very extensive frontal sinus, which extends into the lateral branches, into the parietal, and even into the occipital.

Frontal smaller in sheep and goat.

In the *sheep* and *goat* the frontal bone is less strong and extensive than in the ox, and does not form the ridge on the summit of the skull. It presents, on its dorsal surface, two rounded eminences, one between the orbits, and one more posteriorly, corresponding to two depressions on its cerebral aspect. The sinuses do not extend further back than the posterior border of the bone, and, like in the ox, it does not articulate with the temporal or palatine.

Pig has thick frontal.

Has a vascular groove on its dorsal aspect.

In the *pig* the frontal is of great thickness and strength. The orbital process is very short, the arch being completed by a ligament. The supra-orbital foramen is on a level with the anterior margin of the orbit, and becomes continuous on the dorsal surface with a groove extending as far as the nasal bones. The internal orbital foramen is entirely formed by this bone. It does not articulate with the palatine, but does anteriorly with the superior maxillary. The sinuses gradually enlarge, and in old animals extend as far as the parietal.

Carnivora.

Dorsal aspect depressed.

Orbital arch incomplete.

In the *dog* and *cat* the dorsal surface of the bone presents in the median line a depression, varying with the breed and getting deeper with age. The orbital process is very short, and completed by a ligament, sometimes ossified in the cat. No supra-orbital foramen exists, but the internal orbital is entirely formed by the frontal. On the cerebral surface is a sulcus in the median line for lodging the longitudinal sinuses. The frontal sinuses do not extend to the parietal;

they communicate directly with the nasal chambers by a narrow opening. The frontal bone in carnivora has no articulation with the temporal, but has to a small extent with the superior maxillary.

ETHMOID.

Name. Position. Form.

The *ethmoid* bone (ηθμος, sieve; ειδος, like), so called from its perforated character, forms the inferior boundary between the cranium and the face, and so may be said to hold on the ventral surface a position somewhat analogous to that of the frontal on the dorsal aspect of the skull. It connects the frontal and the sphenoid in the median line anteriorly, and articulates by its other borders with the vomer, the palatine, and the superior maxillary. It is irregularly cubical in form, but for the purposes of description may be divided into a *median perpendicular lamina* and two *lateral masses.*

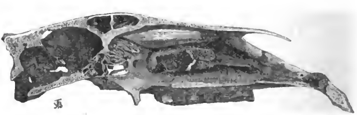

Fig. 81. Section of Horse's Head, showing the cranial cavity separated from the nasal chambers by the ethmoid bone with its cells. Nasal chambers, with the turbinated bones. The inferior turbinated bone is broken at the posterior part, to show the opening of the antrum maxillare.

To place the bone in the proper position for description, the perforated surface must be posteriorly, and the laterally expanded part of the compact median plate superiorly.

Vertical plate.

The *perpendicular lamina* is a compact plate, situated vertically in the median line, and forming a central pillar of support to the bone; it has two surfaces and four borders.

Surfaces.

The *surfaces* are smooth, except at their posterior part, where some minute wavy crests break their uniformity. They are covered by pituitary membrane, and are separated from the lateral masses by narrow intervals, forming the extremities of the nasal chambers.

Borders. Crista galli. Ethmoid fossæ.

The *superior border* is continuous with the bony plate which separates the two frontal sinuses in the median line. The *inferior* becomes continuous at its posterior part with the lamina separating the sphenoidal sinuses, and is received at its anterior part into the sulcus on the superior margin of the vomer. It becomes ossified with time, both with the sphenoid and vomer. The *posterior border* is thick and smooth, forming the *crista galli* or ethmoidal crest, which projects between the hemispheres of the brain anteriorly, and leads to the formation of two lateral cavities (ethmoid fossæ) for the reception of the anterior lobes of the brain (olfactory bulbs). It is rounded inferiorly and continuous with the spine of the sphenoid; superiorly it has a median ridge with two lateral triangular surfaces, and becomes continuous with the median ridge on the frontal. The *anterior border* is continuous with the cartilaginous septum of the nose, which, when ossified, is inseparably united to it.

Lateral masses formed of numerous cavities, called ethmoid cells; cribriform plates.

The *lateral masses* are two great pyriform, spongy bodies attached posteriorly to the plates forming the anterior walls of the ethmoid fossæ, and projecting anteriorly into the nasal chambers. Each is made up of numerous exceedingly attenuated osseous laminæ, rolled up into minute horn-like projections of extreme fragility. To these the name of *ethmoid cells* has been given, while the posterior perforated laminæ are termed *cribriform plates*. Each *lateral mass* may be divided into a median part, a base, and a summit.

External surface. Anterior part. Posterior part. Internal surface.

The *median part* presents, on its external surface, an anterior and posterior division; the former belonging to the nasal chambers, the latter forming part of the internal wall of the nasal and maxillary sinuses. The *anterior* division, formed by the ethmoid cells, is nearly smooth, is parallel with the central lamina, and exhibits various openings forming the spaces between the more superficial cells, and generally opening into their internal cavities. The *posterior* division is convex and is continuous with the cribriform plates, seeming as it were a lateral and anterior prolongation of these for the closure of the frontal sinuses, and to unite with the palatine and superior maxillary bones. It shows small transverse grooves corresponding to little crests on which the ethmoid cells are attached. The *internal surface* presents several canals proceeding in a transverse direction from the perpendicular lamina, opening anteriorly into the nasal chambers, and dividing the cells into transverse rows. These canals are so arranged that the greater part of the cells communicate freely

Cells in transverse rows.

with each other. Both the cells and the intervening spaces are most voluminous toward the dorsal aspect, and diminish in size from above downward.

Base.

The *base* of each forms the anterior wall of the corresponding ethmoid fossæ, and is interposed between the cranium and the nasal chambers. It is thickly perforated by holes for the passage of the olfactory nerve, from which it has received the name of cribriform plate. It is concave posteriorly for lodging the olfactory bulbs, and convex anteriorly, with transverse ridges for the attachment of the ethmoid cells. It is continuous in the median line with the perpendicular plate, and joins the frontal superiorly, and the sphenoid inferiorly and laterally.

Cribriform plate.

Summit.

The *summit* is formed by the free extremities of the ethmoid cells, and is most prominent on its dorsal aspect, from one of these being much larger than the others. The cell in question corresponds to the median turbinated bone of man.

Articulations.

The ethmoid articulates with twelve bones,—the frontal, the sphenoid, two palatine, two lacrymal, four turbinated, and two superior maxillary bones.

Structure.

This bone is formed chiefly of the very attenuated and perforated laminæ already mentioned, but its only true spongy tissue exists at the posterior border of the perpendicular plate.

Development.

Bony deposition is later in this than in surrounding bones. Ossification commences in the bony plates of the external surface and the free ends of the ethmoid cells, and progresses inwardly in a somewhat tardy manner. The cribriform plates and the perpendicular lamina are accordingly the last to become ossified, and are sometimes cartilaginous up to the sixth or eighth month after birth.

Ox has large ethmoid cells.

Differences.—In the *ox* the first of the ethmoid cells on the dorsal surface is enormously developed, so as to form in appearance a third turbinated bone. This has been called the olfactory sinus (Rigot) and communicates superiorly with the frontal sinus.

Carnivora have large ethmoid fossæ and cells.

In the *carnivora* the ethmoid fossæ are very deep, and the ethmoid cells largely developed. This provision is evidently to allow a wider distribution of the olfactory nerves, and to ensure the delicacy of smell characteristic of this order. The perpendicular plate is late in being ossified to the sphenoid.

SPHENOID.

Name. Position. Form.

The sphenoid bone (σφην, wedge; εἶδος, form) is so called from its wedge-like position between the other bones of the cranium. It is placed on the ventral aspect of the cranium, in the median line, between the basilar process of the occiput and the ethmoid, at the same time articulating laterally with the other cranial bones, and anteriorly with the vomer. It presents a concavity, from side to side, on its internal or cerebral surface, and a convexity in the same direction on its external or guttural surface.

Has a body and processes.

It is possessed of a body with lateral alæ, which give it a resemblance to a bat, with its wings expanded in the act of flight, two inferior less expanded processes (pterygoid) corresponding to the feet, and the ethmoid spine to the head.

Place the bone so that the alæ project outward, and upward, the thickened leg-like portion downward, the solid part of the body backward, and the hollow part forward.

Body. Ethmoid spine. Processus olivarius. Optic foramina. Pituitary fossa. Lower surface. Joins the occiput behind. Rostrum. Sphenoid sinuses.

The *body* presents on its *cerebral aspect* a square, flattened surface anteriorly, with a projection (ethmoid spine) becoming continuous with the *crista galli* of the ethmoid. This is terminated posteriorly by a transverse border, which forms the anterior border of another plain, but less elevated, surface (processus olivarius), on which decussate the optic tracts. At the antero-lateral parts of this space are two foramina for the transmission of the optic nerves (optic foramina). Still more posteriorly is a central depression (pituitary fossa), varying in depth for the reception of the pituitary body, called also *Sella Turcica*, from a supposed resemblance to a Turkish saddle. On each side of the fossa is a depression corresponding to the cavernous sinus. The *external* or *guttural surface* is convex from side to side, and bears asperities for muscular attachment. From the roots of the pterygoid processes project forward and slightly outward two thin laminæ, forming the outer walls of the sphenoidal sinuses, and articulating with the margins of the vomer. The *posterior aspect* of the body is tolerably smooth, articulating with the basilar process of the occiput. The *anterior* shows a small, inferior, rounded mass (rostrum) joining the central part of the vomer, and two lateral irregular cavities (sphenoidal sinuses), divided by a thin partition, which becomes continuous with the perpendicular plate of the ethmoid, and is sometimes perforated by the progressive increase of the sinuses in aged horses. They communicate anteriorly with the maxillary si-

Open into the maxillary.

nuses. The lateral aspects of the body are continuous with the alæ and pterygoid processes.

Alæ.

The *alæ* are, on each side, divided into two parts—the anterior thin, smooth, and rounded laterally; the posterior thick, notched, covered with ridges, and perforated with foramina. These *anterior* and *posterior alæ*, with the corresponding parts of the body, are quite distinct in early life, and only become inseparably united with the ossification of the sutures generally.

Anterior alæ,

are the larger.

Internal orbital foramen.

Foramen lacerum orbitale.

Optic foramen.

The *anterior alæ* spring from the supero-lateral parts of the body, from its anterior extremity as far back as behind the surface for the decussation of the optic tracts, and are more extended laterally than the posterior. They are thin and somewhat transparent, concave internally for the reception of the lateral parts of the hemispheres of the brain, convex externally where they enter into the formation of the orbits. The anterior border of each is regularly concave, uniting with the cribriform plates of the ethmoid bone, and near its union with the body having a notch, which, with a corresponding one on the frontal bone, forms the internal orbital foramen. The lateral and posterior borders are irregularly convex, and articulate with the frontal, the parietal, and the posterior ala. At the root of the ala posteriorly is a large notch, continuous with a groove running anteriorly, which, with a corresponding groove on the posterior wing, forms the foramen lacerum orbitale; anteriorly to this is situated the optic foramen.

Posterior alæ.

Internal aspect.

Sphenoidal hiatus.

Its foramina.

Outer aspect

Pterygoid process.

The *posterior alæ* are less regular than the anterior. On the *internal surface*, each bears a well-defined antero-posterior crest, continuous with the parieto-temporal ridge, forming with the lateral part of the body the sphenoid hiatus, in the depth of which are three foramina—posteriorly the *foramen rotundum*, formed entirely by the posterior ala; in front of it is the *foramen lacerum orbitale*, superiorly to which and separated from it by a very delicate lamina, is the *foramen patheticum;* the two last are formed by the union of the alæ. Outside the two ridges are two cavities for the reception of the mastoid lobes of the brain. The *external surface* is smoother and somewhat concave, and projecting from its anterior part, in a downward and forward direction, is the pterygoid process.

Vidian canal.

The pterygoid processes are flattened from side to side, and curved outward, with somewhat tuberous extremities. They unite with the palatine bones, and give attachment to the pterygoid muscles. At the inner aspect of the base of each is a groove entering into the formation

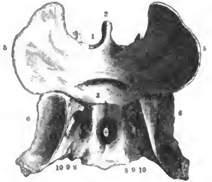

Fig. 82. View of the upper surface of the Sphenoid Bone. 1 to 1, Body; 2, Ethmoid spine; 3, Processus olivarius, on either side and in front of which are the optic foramina covered by a projecting ridge; 4, Pituitary fossa; 5 5, Anterior alæ; 6 6, Posterior alæ; 7 7, Sphenoidal hiatus, in which are the foramen rotundum, foramen lacerum orbitale, and foramen patheticum; 8 8, Carotidean notch; 9 9, Notch for the inferior maxillary nerve; 10 10, Notch for the middle meningeal artery.

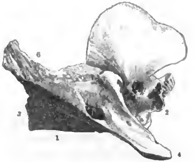

Fig. 83. Side view of the Sphenoid Bone. 1, Body; 2, Lamina contributing to the formation of the sphenoidal sinuses; 3, Posterior part of body; 4, Pterygoid process; 5 and 6, Anterior and posterior alæ; 7, Sub-sphenoidal foramen; 8, Optic foramen.

Sub-sphenoidal foramen. **Borders of the posterior alæ.** **Carotidean notch.** **Orbital hiatus.** **Vidian canal.** **Sub-sphenoidal foramen.** **Lacerated orbital.** **Foramen patheticum.** **Optic foramen.**

of the vidian canal, and at their root posteriorly is the sub-sphenoidal foramen, which bifurcates anteriorly, the larger division entering the orbital hiatus, and transmitting the internal maxillary artery; the smaller, separated from the superior part of the last by a thin plate, affords passage to some anterior temporal branches. The *external border* is thick, denticulated, and slightly squamous, for articulation with the squamous part of the temporal bone. The *posterior*, projecting backward, forms the anterior border of the foramen lacerum basis cranii, and presents various notches, corresponding to the structures passing through that aperture. The internal of these transmits the internal carotid, and is called by Rigot the carotidean notch; the median corresponds to the foramen ovale of the sphenoid of man, and transmits the inferior maxillary nerve, while the outer, a very small notch, represents the foramen spinosum of man, and transmits the middle meningeal artery. The *anterior border* is thick, and directed obliquely forward and downward, becoming continuous with the anterior border of the pterygoid process. Near its superior angle it contains the small foramen, already mentioned, communicating with the sub-sphenoidal foramen and the foramen lacerum orbitale. Between its anterior border and the anterior ala is enclosed on each side an oval hiatus (orbital hiatus), into which open the following foramina:—(*a*) The minute anterior opening of the vidian canal for the passage of the vidian nerve; (*b*) more superiorly, the anterior opening of the sub-sphenoidal foramen, for the internal maxillary artery; (*c*) still higher, and formed by the apposition of the anterior and posterior alæ, the foramen lacerum orbitale, for the passage of the third and sixth nerves, the ophthalmic branch of the fifth nerves, and the ophthalmic vein; at the superior part of this, the foramen patheticum for the fourth or pathetic nerve; still more superiorly, and formed by the anterior ala alone, is the optic foramen for the transmission of the optic nerve and ophthalmic artery.

Articulations.

The sphenoid articulates posteriorly with the occipital, laterally with the temporals, parietals, and frontal, anteriorly with the ethmoid and vomer, and inferiorly with the palatine bones.

Structure.

The alæ are very compact, but the body contains much cancellated tissue.

Development.

The sphenoid is in the young animal readily divisible into two parts, the anterior, containing the fore part of the body, the sphenoidal sinuses, the rostrum, and the anterior alæ; the posterior, containing the back part of the body, with the posterior alæ, and the pterygoid processes. The anterior part is frequently united to the ethmoid, even before its union with the posterior division, and it has accordingly been described by some anatomists (Percival, Tabourin) as a part of the ethmoid.

Each of these divisions has its own centres of ossification, one for the body (sometimes two, one on each side), and one on each side for the processes.

Differences.—In the *ox* the bone is shorter, and its pterygoid processes are longer and thinner than in the horse. They contain no subsphenoidal foramen. The sella turcica is much deeper, and the sphenoidal hiatus is not divided anteriorly into three foramina, but opens into the orbit by a single large aperture. In place of the notches on the posterior border, there exists a large foramen (foramen ovale of man), for the passage of the inferior maxillary nerve, and the median meningeal artery.

Sphenoid of the ox.

Sphenoidal hiatus undivided.

Foramen ovale.

In the *sheep*, just behind the sella turcica, is an elevation, projecting forward and outward, and flattened from before backward, corresponding to the *posterior clinoid processes* in man. These are sometimes found in the cow as well.

Sheep and goat.

Clinoid processes.

In the *pig* the bone is very short, and the pterygoid processes largely developed, flattened from before backward, and containing no subsphenoidal foramen. The sella turcica is deep, and bounded posteriorly by prominent *posterior clinoid processes.* The sphenoidal hiatus, like in the ox, continues a single opening throughout. The alæ are small, and articulated by harmonic sutures with the lateral parts of the frontal.

The pig has large pterygoid processes without a hole.

Clinoid processes.

Sphenoidal hiatus undivided.

In the *dog* the sphenoid approaches more to its structure in man. The body is short. The pterygoid processes are very slightly developed, and have at their base a subsphenoidal foramen opening into the foramen rotundum, and not divided anteriorly like in the horse. Of the alæ, the posterior are much the larger, and are continued back so as to form part of the temporal fossa; the anterior are very small, and the body at this part is correspondingly narrow. The pituitary fossa is shallow, and is surrounded by four processes, the posterior clinoid processes, and approaching these from the anterior side two projections from the anterior alæ—the anterior clinoid processes. The sphenoidal hiatus opens into a foramen rotundum, and a foramen ovale, but there is no separate foramen for the pathetic nerve. The posterior border contains on each side a notch destined to form with

Carnivora.

Four clinoid processes.

No foramen pathetica.

a notch of the temporal, the carotidean foramen, while for the inferior maxillary nerve a *foramen ovale* is formed by the ala.

Cat has no subsphenoidal foramen. The chief differences in the *cat* are, the want of a subsphenoidal foramen, and of a notch for the carotidean opening, while the four clinoid processes are frequently connected by thin bony plates.

TEMPORAL BONES.

Why named. The *temporal bones* (ossa temporis) are so named from the fact that, over them in the human subject the hair first becomes gray, thus Situation. indicating the ravages of time. They are situated in the lateral parts of the cranium, are surrounded by, and articulate with, all the cranial bones, with the exception of the ethmoid, and with three of the facial bones, the superior and inferior maxillary, and the malar, to the first and last by synarthrosis, to the inferior maxillary by diarthrosis. Two parts. Each bone is composed of two parts, articulated together by simple union (harmonia)—the anterior, called the squamous, from its scaly appearance, the posterior, called the petrous, from its hardness, or the tuberous, from its roughened character.

Squamous portion.—This is flat and thin, convex externally, concave internally; presenting for consideration two surfaces and a circumference.

Outer aspect has various holes. The *external surface*, which bounds the temporal fossa internally, is convex, with roughness for muscular insertion, and various foramina towards its posterior part, penetrating the parieto-temporal Zygomatic process. canal. From its median part projects, at a right angle, the zygomatic process, which bends suddenly forward, forming the external boundary of the temporal fossa, and terminates by a sharp point, bevelled and denticulated inferiorly for articulation with the zygomatic projections of the malar and superior maxillary bones. The whole arch formed by the union of these processes is known as the zygoma or zygomatic arch. The zygomatic process is flattened from above downward, and pierced by a vascular foramen at its root. After its bend it is somewhat prismatical, having three surfaces, viz., internal, external, and inferior. The former of these is concave, bounding the temporal fossa externally, and giving attachment to the temporal muscle; the next is convex, and has only a thin aponeurosis between it and the skin; the inferior is roughened for the attachment of the masseter muscle. Its superior border is sharp and rough posteriorly, for the attachment of the aponeurosis of the temporal muscle; toward its anterior surface it presents an oval denticulated surface for the reception of the orbital process of the frontal; in front of this is a small concave and smooth surface entering into the formation of the orbit. The process originates from two roots, posterior and anterior. The former is only a curved crest, continuous with the mastoid crest of the occiput, and forming the posterior boundary of the temporal fossa; the latter, projecting from the bone at a right angle, bears inferiorly the surface of articulation for the lower jaw; this consists of (*a*), anteriorly a condyle convex from before backward, and concave from side to side; (*b*) behind this a limited glenoid cavity, widest internally, and limited posteriorly by a mammiform process (supra-condyloid). Immediately behind this is a large notch continuous with a fissure, entering into the formation of the parieto-temporal canal.

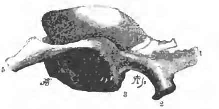

Fig. 84. Squamous portion of Temporal Bone, showing the zygomatic process with its double roots. 1 Posterior; 2, Anterior; 3, Supra-condyloid process; 4, Articulating surface; 5, Orbital extremity of the zygomatic process.

Has an anterior and a posterior root.

Anterior has articular surface for the lower jaw; a condyle and glenoid cavity. Supra-condyloid process. Orifice of parieto-temporal canal.

The *internal* or *cerebral surface* is slightly concave, marked by *impressiones digitatæ*, and bears arborescent grooves for the ramifications of the meningeal arteries.

Internal aspect.

The *circumference* may be divided into two borders, of which the superior is convex, and articulates with the parietal and frontal by its inner aspect, which is squamous and denticulated; the inferior border is likewise convex, and is bevelled on its inner aspect anteriorly, in order to articulate with the sphenoid; posteriorly it is smooth, for articulating with the *tuberous portion*, having two large notches, the anterior for the reception of the external auditory canal, the posterior for the mastoid portion of the *tuberous part*. At its superior extremity it has a very limited articulation with the occipital bone.

Two borders.

Lower border has two notches.

Structure. It is composed of two thin compact plates with a minute quantity of intervening cancellated tissue, except in the zygomatic processes, in which a considerable amount of spongy tissue exists.

Development. It is developed from a single centre of ossification.

Holds essential organs of hearing. The *tuberous* or *petrous portion*.—This part is of great importance as containing the organs of hearing, viz., the cavity of the tympanum, the middle and the internal ear. These parts, however, will be noticed when treating of the organs of special sense; at present we have only to do with the external characters of the bone.

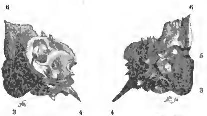

Fig 85. Fig. 86.

Fig. 85 Internal or Cranial Surface of Petrous Temporal Bone. Fig 86. External Surface of the same. 1, Internal auditory meatus; 2, External auditory meatus; 3 3, Mastoid process; 4 4, Styloid process; 5, Mastoid fissure; 6 6, Apex.

Position. It is enclosed between the antero-lateral borders of the occipital, the lateral border of the parietal, and the squamous portion of the Form. temporal, and is in the form of a quadrangular pyramid, having four surfaces, four borders, a base, and a summit. Its base is turned downward and backward; its summit fitted like a wedge into the point of union of the occipital and parietal bones.

Surfaces. The *anterior surface* articulates with the parietal by a harmonic suture. The *posterior* unites in the same manner with the occipital. The *external* unites at its anterior part with the squamous portion, Mastoid fissure. and has on its surface a groove (mastoid fissure) running forward to the parieto-temporal canal. The *internal* is concave, with *impres-* Inner aspect has internal auditory meatus. *siones digitatæ*, for the convolutions of the cerebellum. It contains the *meatus auditorius internus*, a small opening leading to several foramina, of which the largest—the anterior—leads to the *aqueduct of Fallopius*, and give passage to the *portio dura*, or seventh nerve. The posterior ones, much smaller, afford passage to the *portio mollis*, or nerve of hearing.

Borders.

The *postero-internal* and the *antero-external* borders do not call for special comment. The *antero-internal* combines with the posterior margin of the parietal to form the lateral crests to which the tentorium is attached. The *postero-external* is roughened, forming the mastoid crest, which is continuous with the occipital crest above, and ends in the mastoid process below. At its middle is the mastoid fissure already mentioned.

Apex.

Its *summit* joins the occiput by a slightly denticulated apex.

Base. **External auditory meatus.** **Mastoid process.** **Aqueduct of Fallopius.** **Styloid process.** **Styloid foramen.** **Hyoid process.** **Mastoid protuberance.**

The base is very irregular, and presents:—(*a*), externally, a hollow bony cylinder (*meatus auditorius externus*) to which the cartilage of the ear is attached; (*b*), internally, a sharp crest, forming the border of the *foramen lacerum basis cranii;* (*c*), posteriorly, the mastoid process, a blunt rounded mass, and immediately internally to this the opening of the aqueduct of Fallopius, for the transmission of the seventh or facial nerve; anteriorly is the styloid process, a long, slender projection, pointed inferiorly, and having, anteriorly to its base, a foramen divided in the fresh state by a small transverse ligament; this orifice gives passage to the tympano-lingual nerve and the Eustachian tube, to the last of which, and the stylo-pharyngeus muscle, the styloid process gives attachment. In the centre, and immediately at the base of the external auditory canal, is a cylindroid eminence (hyoid process), surrounded by a bony sheath (vaginal process of man), and internally to this a somewhat angular mass (mastoid protuberance), which, with the mastoid process, corresponds to the mastoid portion in man, both being hollowed internally to contain the mastoid cells

Various other peculiarities, more especially connected with the internal parts of the bone, will very properly be considered when treating of those important structures to which it affords protection.

Development.

The ossification proceeds from four nuclei. These are:—1. One for the petrous part of the bone; 2. One for the mastoidean part; 3. One for the hyoid process; and, 4. One for a small bony circle, incomplete superiorly, at the internal extremity of the meatus auditorius externus, and called the tympanic bone, from its giving attachment to the tympanum. The superior and internal parts of the bone, containing the internal ear, are developed from the first of these centres; all the base, except the meatus auditorius externus and hyoid process, form the second.

Structure.

In no bone in the body does the same amount of compact tissue exist in so limited a space. The petrous portion contains a considerable thickness of bone, of an ivory consistence throughout, while the mastoid part is hollowed internally, and consists of compact tissue only.

Differences.—The horse is the only one of our domestic animals in which the zygomatic process of the temporal articulates with the superior maxillary bone.

Ruminants.

Ox has large zygomatic process.

Large condyle.

Great mastoid process.

No mastoid fissure.

In the *ox* the zygomatic process is largely developed, more especially its roots. The condyle is larger and more elliptical, and posteriorly to the glenoid cavity is a second convex articulating surface. The mastoid process is very prominent, and attached to the squamous part. This, with the mastoid crest, is confounded with the posterior root of the zygomatic process. There is no mastoid fissure. The parieto-temporal canal, larger than in the horse, opens superiorly at the summit of the petrous portion, inferiorly it presents several orifices. The meatus auditorius externus turns directly outward, not upward as in the horse. The mastoid protuberance situated at the internal part of the tuberous division of the bone, is largely developed, is enclosed by a thin bony plate, and contains minute cells in the vicinity of the tympanum, which are surrounded by and communicate with cells of much larger size.

Great mastoid protuberance.

Sheep and goat analogous.

In the *sheep* and *goat* the same disposition is met with. The mastoid process is, however, little marked, and the mastoid part of the bone is late in uniting with the petrous.

In the pig the condyle is longer from before backward.

In the *pig* the articular surface for the lower jaw approaches in form to that of the rodents, being much reduced in its lateral, and greatly elongated in its antero-posterior dimensions. The zygomatic process, flattened laterally, articulates with the malar along its whole inferior border. Its superior border does not receive an orbital process from the frontal. Its posterior root is confounded with the mastoid crest. There is no parieto-temporal canal, no mastoid nor hyoid process, but the styloid process exists in a rudimentary condition. The mastoid protuberance is enormously developed and ovoid, with a crest leading from its posterior surface along the posterior wall of the external auditory meatus to join the mastoid crests.

No parieto-temporal canal, mastoid, nor hyoid processes.

Large mastoid protuberance.

In carnivora the articular surface is a glenoid cavity.

In the *dog* and *cat* the condyle of the temporal is replaced by a simple glenoid cavity, corresponding to the condyle of the lower jaw. The supra-condyloid process is hooked forward. The external auditory meatus is of great size. The temporal fossæ are relatively much

Large mastoid protuberance. Carotid canal.

larger and deeper than in other animals. There are no mastoid, hyoid, or styloid processes, but the mastoid protuberance is largely developed, more especially in the cat. Two canals peculiar to these animals deserve notice. One, the *carotid canal*, at the antero-internal part of the mastoid protuberance, opens into the cranium, and communicates posteriorly with a venous canal interposed between this bone and the basilar process of the occiput. The other pierces the petrous part of the bone just above the carotid canal, and affords an exit to one of the fifth pair of nerves.

Rabbit.

In *rodents* the articular surface corresponds to that of the pig, but is even shorter in its transverse diameter.

II.—BONES OF THE FACE.

Face chiefly modified hæmal arches.

The face, as already mentioned, is composed of twenty bones, mostly representing the hæmal arches of the two first vertebræ of the skull, and, consequently, holding a position in the head analogous to that of the ribs in the dorsal region. The extreme modifications are accounted for by the purposes of mastication, &c., to which these arches are adapted.

SUPERIOR MAXILLARY BONE.

Situation. Form.

This bone (maxilla superior) is situated on the side of the face, articulating posteriorly with the frontal, the palatine, the zygomatic process of the squamous temporal and the lacrymal; in front, with the anterior maxillary; above, with the nasal, and internally with its fellow. It is longest in its antero-posterior direction, and is irregularly prismatical, being most bulky at its middle part, and diminishing gradually toward either extremity, especially the anterior. It has three surfaces, three borders, and two extremities.

Surfaces. External. Superior maxillary spine. Infra-orbital foramen.

The *external surface* is slightly concave anteriorly, and convex posteriorly, as best seen in the very young animal. From the level of the third molar tooth backward, runs a prominent crest (superior maxillary spine), becoming continuous posteriorly with the inferior border of the zygoma, and giving attachment to the masseter muscle. More superiorly is a large foramen (infra-orbital.)

Inner aspect divided into two.

The *internal surface,* covered in the living animal by pituitary membrane, consists of two parts, one looking directly inward, the other upward. The latter forms the floor of the nasal cavities, and

Maxillary sinus. Palatine canal. Crest. Lachrymal orifice.

shows some slight grooves arranged longitudinally, corresponding to venous canals by which it is traversed. The former, much more extensive, forms the lateral wall of the nasal cavity. It presents, supero-posteriorly, a large cavity, forming part of the maxillary sinus; infero-posteriorly is a slightly denticulated flat surface for articulation with the palatine, and bearing a groove which, with a similar groove on the last-named bone, forms the palatine canal; between these parts is a horizontal crest giving attachment to the inferior turbinated bone, above which is the orifice of the lachrymal duct, continued by a well-marked groove as far as the inferior border of the bone.

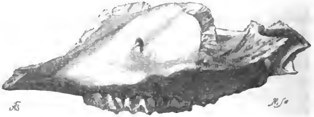

Fig. 87. Superior Maxillary Bone, indicating the position of the temporary molar teeth, the infra-orbital foramen, and the squamous edges of the bone.

Lower aspect. Palatine groove.

The *inferior* or *buccal surface*, slightly concave from side to side, forms the greater part of the roof of the palate. A well-marked groove runs throughout its whole length, close to its outer margin (palatine groove), for lodging the palatine artery and nerve. More internally numerous small longitudinal furrows for the accommodation of veins, give the surface a rugose aspect.

Borders.

The *superior border*, thin and convex, is mortised in its anterior two-thirds for articulation with the anterior maxillary and the anterior part of the nasal; the posterior third is bevelled towards its outer aspect, to unite with the nasal and malar bones.

External has six deep cavities.

The *external border* is very thick, and contains six large quadrilateral cavities (alveoli) for the reception of the molar teeth. The four last alveoli project into the maxillary sinus, but are separated from its cavity by a thin bony lamina. Behind the last alveolus is

Alveolar tuberosity.
Interdental space.

an eminence (alveolar tuberosity), affording attachment to the buccinator muscle. Anteriorly to the first alveolus the border is sharp, becoming more rounded towards its anterior part.

The *internal border* is denticulated throughout the greater part of its extent, to articulate with its fellow on the opposite side; anteriorly it bears a notch for the reception of a prolongation of the anterior maxillary; at the anterior part of this notch is a smooth border, forming the external wall of the lateral incisive opening.

Extremities.

Superior maxillary hiatus.

The *posterior extremity*, the larger of the two, presents inferiorly a tuberosity containing an extension of the maxillary sinus. Above, and internally to this, is a large hiatus, partially formed by the palatine, in the depth of which are three foramina; the internal or lateral nasal, opening into the posterior naris; the median or palatine, admitting the palatine artery to the mouth; and the external or superior maxillary, giving passage to the blood-vessels and nerves of that name. These traverse the maxillary sinus, supplying the alveoli with blood and nervous influence, and on a level with the third molar, the canal divides into two branches, one of which opens on the external surface of the bone (infra-orbital foramen), while the other is lost, opposite the first molar tooth.

Anterior end has alveolus in the male.

The *anterior extremity* is squamous, and in the horse, bears a cavity which, with the anterior maxillary, forms an alveolus for the reception of the tush.

Structure.

The spongy tissue exists most largely toward the superior extremity and along the alveolar border of the bone, being most abundant in the young animal. The maxillary sinus, like similar cavities, increases in size with the advance of age.

Development.

Development takes place from a single centre of ossification.

In the ox the spine is a row of tubercles.

No alveolus for the tush.

Differences.—In the *ox* the superior maxillary spine is rough and tuberculated, and is indirectly connected with the zygomatic arch by a curved line, concave inferiorly. The infra-orbital foramen opens on a level with the first molar tooth. The palatine canal does not penetrate this bone. There is no alveolus at its inferior extremity for the reception of the tush. The sinus is much larger than in the horse, and extends between the laminæ of the palatine process.

Sheep and goat.

In the *sheep* and *goat*, it concurs to the formation of the palatine canal, and the sinus does not extend into the palatine process.

In pig is concave externally, has more alveoli.

In the *pig* the external surface of the bone is concave. The external border is rounded anteriorly for the reception of the canine teeth. There is no alveolar tuberosity, the maxillary sinus is very small, and the interdental space is little marked. The bone projects backward into the cavity of the orbit, and itself forms the anterior opening of the palatine canal.

Forms palatine canal. Carnivora have no spine.

Has a cavity for the tush.

In the *dog* this bone is short and presents no *spine*. The external division of the maxillary canal opens like in the horse and pig, opposite the third molar tooth. Superiorly the bone is elongated for articulation with the frontal. Anteriorly it is bulky and contains an alveolus for the tush. The posterior part of its palatine process enters into the formation of the palatine foramen. The maxillary sinuses are very small.

Differences in the cat.

In the *cat* it is shorter in an antero-posterior, and longer in a vertical direction. The superior dental canal is represented by a groove traversing the floor of the orbit, and by an aperture through the thin lamina at its anterior part.

ANTERIOR MAXILLARY BONES.

Position.

Division.

The *anterior maxillary bones* (maxillæ anteriores), form the anterior extremity of the upper jaw, being situated immediately in front of the bone last described. Each consists of an anterior bulging and prismatic part, with two projections elongated posteriorly.

Anterior part.

Foramen incisivum.

Interdental space

The *anterior part* presents three surfaces and three borders. The *external* or *labial surface* is convex, smooth, and covered on its inferior half by mucous membrane. The *internal* is denticulated to articulate with the bone on the opposite side, and presents in its median part a curved groove which enters into the formation of a canal leading to the foramen incisivum. The *inferior surface* is smooth and concave, presenting several minute foramina and the continuation of the palatine groove, which terminates anteriorly in the posterior incisive foramen. The *superior* and *inferior borders* present nothing remarkable, if we except the notches for the foramen just named. The external presents anteriorly a curved line with its convexity outward, and containing three alveoli for the reception of the incisor teeth; posteriorly, a narrower, smooth, and straight border, entering into the formation of the interdental space.

Processes.

External.

The *processes* may be considered as an external and an internal. The former, the largest in every sense, is flattened from side to side, and presents two surfaces and two borders. The external surface, smooth and slightly convex, is continuous with the external surface of the *anterior part;* the internal surface, also smooth, forms part of the external wall of the nasal cavity; the superior border is smooth and rounded, with an eminence anteriorly for the insertion of the muscles of the alæ nasi, and a small denticulated space posteriorly for articulation with the nasal bones; the inferior, continuous anteriorly with the alveolar border, is denticulated throughout for articulation with the superior maxillary bone. The *internal process* is flattened from above downward, and has a prismatical form posteriorly, so as to give it the appearance of a small tongue. Between its lateral parts and the alveolar portion of the bone is an opening (fenestra incisiva) closed by cartilage in the natural condition. Its superior surface forms part of the floor of the nasal cavity, its inferior, part of the roof of the mouth; its external border unites by its posterior part with the superior maxillary bone, its internal by denticulations with the similar process of the opposite bone.

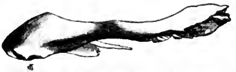

Fig. 88. Anterior Maxillary Bone, indicating its processes.

Internal tongue-like.

Incisive opening.

The anterior maxillary contains a large amount of spongy tissue covered by a thin compact layer. The cancellated structure in the anterior and thickest part of the bone, is greatest in early youth, and almost entirely disappears when the bone is fully developed.

Structure.

Ossification takes place from a single centre first seen in the middle of the labial surface.

Development.

Differences.—In these animals the anterior part is flattened from above downward, and in place of alveoli presents simple roughnesses for the attachment of a fibro-cartilaginous pad. It is separated from its fellow by a deep notch anteriorly, and the fenestra incisiva is of great size. It does not articulate with the nasal, and is seldom completely ossified to its fellow, or to the superior maxillary bone even at an advanced age.

In the ox has no alveoli.

Seldom anchylous to other bones.

In the pig the external process of the bone is greatly enlarged, and its superior border articulates by its posterior two-thirds with the nasal. There is no incisive foramen, the palatine artery gaining exit between the two first incisor teeth.

Pig has the external process larger.

No incisive hole.

In carnivora the anterior maxillary bone is of small size, destitute of a foramen incisivum, and having, like the pig, an oval fenestra between its internal and external processes.

In carnivora small, and no foramen incisiorum.

NASAL BONES.

Position. These bones (ossa nasi) are situated on the supero-anterior part of **Form and division.** the face, having the frontal and the lachrymal posteriorly, the superior and the anterior maxillary inferiorly. Each of these bones is triangular, elongated in their antero-posterior direction, flattened from **Surfaces.** above downward, and has *two surfaces, two borders*, a *base*, and a *summit*. The base of the triangle should be placed posteriorly, the apex anteriorly, and the straight border internally.

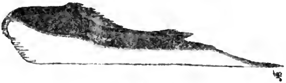

Fig. 89. Nasal Bone.

The *external surface* is generally smooth and convex from side to side.* Its *internal surface* concave from side to side, has near its external border a crest, arranged in an antero-posterior direction, giving attachment to the superior turbinated bone, and forming the division between the superior and inferior meati of the nose. At its posterior part the crest bifurcates, enclosing a space which enters into the formation of the frontal sinus.

Borders. The *external border* is thin and sharp in its posterior two-thirds being bevelled on its internal aspect for articulation with the lacrymal, the superior and the inferior maxillary bones. Its anterior third, smooth and rounded, has an indentation posteriorly, and, separating from the anterior maxillary bone, forms with it an acute angle opening anteriorly. The internal border is much thicker, and denticulated for articulation with the opposite bone. By their union they form a crest internally, which is embraced by, and supports, the cartilaginous septum of the nose.

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* In some horses the nasal bones are convex in their median part in an antero-posterior direction, the internal surface presenting a corresponding concavity. This condition is called roman-nosed, and is generally met with in animals with no great pretensions to breeding. Sometimes the opposite form is met with either congenitally or as the result of pressure from the bridle or other agent. In the latter case, the bone is rendered much thinner, and sometimes even perforated by the continued pressure. The size and length of these bones are characteristic of well-bred horses.

Base.

Their *base* is convex and bevelled on its inferior aspect for articulation with the frontal. When the two bones are placed in apposition, this convexity causes a deep intervening notch, which gives them a heart-shaped aspect.

Apex. Nasal spine.

The apex ends in a point, to which the nasal cartilages are attached. With its fellow it forms the nasal peak, while all that part having no articulation with the anterior maxillary bone, has been called the nasal spine.

Structure and ossification.

It is nearly compact throughout, and is developed from a single centre of ossification.

In the ox. Bifid anteriorly.

Differences.—In the *ox* the nasal bones are much smaller than in the horse, and never undergo perfect union between themselves nor with the bones around. Posteriorly, each terminates by an angle, received into a notch on the frontal bone. Anteriorly, each ends in two points, separated by a notch of some depth. Their articulation with the superior maxillary bone is much more limited than in the horse.

Sheep and goat.

In the *sheep* and *goat* each terminates by a single point inferiorly.

Very large in the pig. Nasal spine is short, with a bone at its apex.

In the *pig* these bones are largely developed, and flattened externally. A groove, continuous with that from the infra-orbital foramen, traverses the superior surface of each. The nasal spine is short, and at its apex is a small trifacial bone, attached to it by fibro-cartilage, and affording attachment to the muscles of the snout.

In carnivora are broadest anteriorly. No spine.

In carnivora the nasal bones increase in breadth from behind forward. They are curved with the concavity superiorly; their external surface is turned inward toward the median line; and, in place of a nasal spine, the bones are cut away so as to form by their union a semicircular notch.

LACHRYMAL BONES.

Why named? Position. Form.

These bones (ossa lachrymalia), so called from their containing a canal for carrying the tears to the nose, are situated in the anterior part of the orbit, between the frontal bone above and the lachrymal below. Each is a thin, flat bone, bent on itself at right angles, and presents two surfaces, internal and external, and a circumference. The bone should be held so that part of the external surface containing the foramen looks backward, and its elongated part postero-inferiorly.

Surfaces.

The *external surface* is divided into two parts, a superior and inferior, by a prominent crest, forming the margin of the orbit ante-

Orbital aspect.

Lachrymal fossa.

riorly. The posterior or orbital part is smooth and concave, forming part of the floor of the orbit. Near the margin of this part it contains an infundibulum, for the reception of the lachrymal sack, and having in its depth an opening leading to the lachrymal canal. Immediately behind the fossa just named is a slight depression for the insertion of the inferior oblique muscle of the eye. The anterior or facial part is nearly smooth, and frequently has, near its median part, a small tubercle for the insertion of the orbicularis palpebrarum muscle. The *internal surface* enters, throughout its whole extent, into the formation of the frontal sinus. It is divided into two parts by a cylindrical eminence, running from behind forward, and containing the lachrymal canal.

Lachrymal canal.

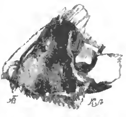

Fig. 90 Lachrymal Bone, showing the opening of the lachrymal duct.

Borders.

It has four very irregular borders, of which the inferior and posterior are the longest. They are all denticulated for articulation with the surrounding bones.

Articulations.

It articulates behind and above with the frontal and nasal, inferiorly and anteriorly with the malar and superior maxillary.

Structures and development.

Composed of compact tissue alone, this bone is most thin and fragile in the orbital part. It has only one centre of ossification.

Larger in the ox.

Differences.—In the *ox* the bone is much larger than in the horse, and its external crest forming the margin of the orbit is less regular and more notched. The lachrymal fossa is placed almost directly on the crest. There is no lachrymal tubercle. On the floor of the orbit the bone expands into a great protuberance (lachrymal tuberosity),* hollow internally, so as to form part of the frontal sinus, and with extremely thin and fragile walls.

Lachrymal fossa nearly on the margin.

Lachrymal tuberosity.

* Chauveau.

Sheep and goat approach the deer. In the *sheep* and *goat* is a well-marked depression immediately anterior to the margin of the orbit.

Pig has two openings to the lachrymal canal. In the *pig* the depression in front of the margin of the orbit is well-marked; the lachrymal canal originates by two orifices placed directly on the margin of the orbit, and about half-an-inch from their origin uniting in the substance of the bone to form a single canal.

The lachrymal fossa, placed well back in the orbit, is very deep.

Carnivora. Very small. In the *dog* and *cat* the bone is extremely small, its internal surface being entirely orbital. It forms only a small portion of the margin of the orbit, and has no lachrymal fossa, but retains the lachrymal foramen.

MALAR BONES.

Situation. The malar bone (os malæ, malare, zygomaticum) is placed at the antero-inferior and external part of the orbit, between the lachrymal bone above and the superior maxillary below. **Form and division.** It is elongated from below backward, irregularly triangular, and may be divided into two surfaces, two borders, a base, and a summit. Place the base anteriorly, the straight border inferiorly, and the smooth surface externally.

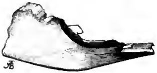

Fig. 91. Malar Bone.

Surfaces. The *external surface* is divided into two parts by an arched border, the concavity of which is turned upward, and which forms the margin of the orbit. The superior portion is smooth and concave, forming part of the orbital cavity; it is pierced by several small foramina. The inferior part is smooth and slightly convex, having anteriorly a depression for the insertion of the nasalis longus labii superioris. The internal surface is hollowed out in its median part, by which it enters into the formation of the maxillary sinus; inferiorly to this it presents a denticulated aspect for articulation with the superior maxillary bone.

Borders. The *superior border* is thin, and denticuated to join the lachrymal. The *inferior* is much thicker, and covered by asperities for the at-

Zygomatic crest.

tachment of the masseter. This border is known as the *zygomatic crest*, and is continuous anteriorly with the superior maxillary spine; posteriorly with the zygomatic process.

Base.

Its *base*, turned anteriorly, is flattened from side to side, very thin and denticulated for articulation with the superior maxillary bone.

Apex.

Its apex is elongated, flattened from above downward, and squamous superiorly for articulation with the zygomatic process of the temporal, with which it forms the zygomatic arch.

Articulations.

It articulates superiorly with the lachrymal, anteriorly and internally with the superior maxillary, and posteriorly by its apex with the temporal.

Structure. Ossification.

This bone is chiefly compact, with a small amount of cancellated tissue towards its inferior border, and at the margin of the orbit. It is developed from a single centre of ossification.

The ox has a large malar. Apex bifid. Sheep and goat.

Differences.—In the *ox*, the malar is largely developed. The zygomatic crest does not form the inferior border of the bone, but describes a curve parallel to the inferior margin of the orbit. The apex is bifurcated, its superior division going to unite with the orbital process of the frontal, its inferior with the temporal. In the *sheep* and *goat* the facial portion of the bone is pierced by several foramina, and has a depression continuous with that formed by the lachrymal.

In the pig the zygomatic part is the largest.

In the *pig* the largest part of the bone is that entering into the formation of the zygomatic arch. This is flattened from side to side, and divided posteriorly into two branches, the interval between which is filled up by the zygomatic process of the temporal; the superior branch is connected with the orbital process by a ligament.

In carnivora the zygomatic part is large.

In the *dog* and *cat* this bone only articulates with the superior maxillary by its base. The zygomatic process, which constitutes almost the entire bone, is curved, with its convexity superiorly, and is bifurcated, but like in the pig, only joins the orbital process of the frontal by a ligament.

PALATINE BONES.

Position. Division.

The palatine bone (os palati), situated at the internal and postero-inferior part of the superior maxillary, forms the posterior part of the bony palate, and with its fellow, almost entirely encircles the posterior opening of the nares. It may be divided into two parts:—an anterior, smaller, flattened from above downward, and a posterior, more extensive, and flattened from side to side. Place the horizontal part of the bone anteriorly, and projecting inwardly, and that margin of the vertical part superiorly which is divided so as to form a deep cavity.

Horizontal part. Surfaces. Borders.

The *horizontal* or *palate* portion of the bone is quadrilateral and smooth on its superior and inferior surfaces, the former constituting the posterior part of the floor of the nasal cavity, the latter forming the posterior margin of the roof of the mouth. This last bears a *notch* for the anterior opening of the palatine canal. The internal border is thick and rough, and by the union with its fellow on the opposite side, forms a slight elevation superiorly, which is embraced by a groove on the inferior border of the vomer. The anterior border is morticed for the reception of a thin lamina of the palatine process of the bone in front, whilst the external one is continuous with the vertical part of the bone. The posterior border, concave, and continued by a ridge on the vertical portion, forms, with its fellow on the opposite side, a parabola, limiting the nares posteriorly, and giving attachment to the soft palate.

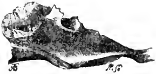

Fig. 92. Palatine Bone.

Vertical part. Surfaces. Line for pterygoid. Borders. Helps to close sphenoidal sinuses.

The *vertical portion* may be divided into two surfaces, internal and external; and three borders, superior, inferior and posterior. The *internal* or *nasal surface*, smooth and convex, forms the lateral walls of the nasal cavities posteriorly. From its supero-posterior angle, running obliquely downward and forward, is a roughened line articulating with the pterygoid bone. The *external surface* is composed of a superior and inferior portion; the former, the smaller of the two, has been called the orbital, from its entering into the formation of that cavity; it is smooth and concave;—the latter, laminated and denticulated, articulates with the superior maxillary, and bears two grooves running obliquely downward and forward, the superior for the palatine artery, the inferior for a lesser vascular twig. The superior border is sharp, in its anterior portion for articulation with the maxillary; behind this, it has its laminæ divided so as to form a deep cavity, which enters into the formation of the sphenoid sinus;

between these is a deep notch for the formation of the lateral nasal foramen. The *inferior border* is thick, having internally a ridge continuous with the posterior border of the horizontal portion; behind the pterygoid bone this ridge takes the name of the palatine crest. The *posterior border* is smooth, and squamous for articulation with the pterygoid process of the sphenoid.

Articulations.

It articulates posteriorly and superiorly with the sphenoid and ethmoid, internally with the pterygoid, and externally and anteriorly with the superior maxillary and vomer.

Structure and development.

It is almost entirely compact, and is developed from a single ossific centre.

In the ox is larger.

Differences.—In the *ox* the horizontal portion is very extensive, and has one or several foramina terminating the palatine canal anteriorly; internally is an irregular cavity continuous with the frontal sinus; the vertical part is a very thin but large perpendicular plate, and the palatine crest is formed by the union of this with the pterygoid bone and the pterygoid process of the sphenoid. It does not form part of the sphenoid sinus.

Sheep and goat.

In the *sheep* and *goat* the horizontal part is not hollow.

Pig.

Pterygoids form a trifid tuberosity.

In the *pig* the horizontal part is comparatively large, but the orbital portion is greatly diminished. The palatine crest is largely developed, and, with the pterygoid on the one side, and the pterygoid process of the sphenoid on the other, forms a remarkable tuberosity, trifid inferiorly.

Carnivora.

Several foramina.

In the *carnivora* the palatine is largely developed; the palatine canal opens by several foramina, and in the anterior border of the bone is a small cavity continuous with the maxillary sinus. It does not form part of the sphenoidal sinus.

PTERYGOID BONES.

Form.

Situation.

Surfaces.

Extremities.

Each pterygoid* (os pterygoides) is a small bone elongated from above downward, flattened from side to side, and placed on the oblique rugose line, on the vertical portion of the palatine. Its external surface is rugose, corresponding to the palatine inferiorly, and to the pterygoid process of the sphenoid superiorly. Its internal surface is smooth and covered by mucous membrane. Its superior extremity is very attenuated, is related by its internal border to the vomer, and enters into the formation of

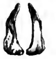

Fig. 98. Pterygoid Bones.

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* Internal pterygoid process of the sphenoid in man.

the vidian canal. Its inferior extremity bulges slightly, is turned slightly backward, and has a smooth, pulley-like surface, over which plays the tendon of the tensor palati. It is composed throughout of compact tissue, and has only one centre of ossification.

Structure and development.

Differences. — In *ruminants*, this bone is larger, but with no tubercle inferiorly. In the *pig* it is comparatively larger than in the horse, and is very tuberous inferiorly. In the *dog* it is very large and quadrilateral, with a thick, rounded inferior border.

Large in the ox. **Pig.** **Dog.**

VOMER.

This bone is so called from its supposed resemblance to a ploughshare. It is lengthened from behind forward, and flattened from side to side, extending in the median line from the sphenoid as far as the anterior maxillary. It has two surfaces, two borders, and two extremities.

Name. **Form.** **Situation.** **Division.**

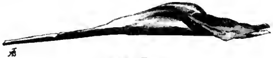

Fig. 94. Vomer.

The *surfaces* are tolerably smooth, having some longitudinal grooves for veins, and are covered by mucous membrane.

Surfaces.

The *superior border* is deeply mortised throughout its entire extent, for the reception of the cartilaginous nasal septum. The *inferior border* is in its posterior third sharp and cutting; anteriorly it presents a slight groove for the reception of the ridge along the line of union of the superior maxillary bones.

Borders. **Upper grooved.**

The *posterior extremity* is flattened from behind forward, and deeply notched, the two lateral parts bearing a resemblance to the ears of a cat; these articulate superiorly with the sphenoid, the ethmoid, the palatines, and the pterygoids. The *anterior extremity*, likewise flattened from above downward, rests on the palatine processes of the anterior maxillary bones.

Extremities. **Posterior notched.**

It is entirely formed of compact tissue, and its ossification takes place from a single centre.

Composition and ossification.

Differences.—In *ruminants*, the vomer is large and thin, and is only supported by the anterior half of the palatine processes of the superior maxillary bones. In most animals it is shorter and thicker than in the horse.

Ox.

TURBINATED BONES.

Number. Form. Position. There are two of these bones in each nasal chamber, a *superior* and an *inferior*. They are irregular bones, convoluted like the ethmoid cells, having a conical form, elongated from behind forward, hollowed out internally, flattened laterally, and attached to the outer wall of the nasal chambers, which they divide into three meati, a superior, an inferior, and a median.

Superior bone. Attachment. Prolonged by fibro-cartilage. Internal cavity is divided. The *superior*, or *ethmoid turbinated bone*, is composed of a very thin, paper-like, compact plate, rolled upon itself from above downward, and attached by its superior border to the crest on the internal surface of the nasal. Posteriorly it is attached to the lateral mass of the ethmoid bone, of which it may be considered as an extension. Anteriorly it is prolonged by a fibro-cartilage, as far as the anterior opening of the nares, forming part of the separation between the false and true nostrils. The internal cavity is divided into a posterior and anterior part, by a transverse bony plate; the former of these forms part of the frontal sinus; the latter, subdivided by a number of smaller lamellæ, communicates with the nasal chamber.

Lower bone. Attachment. Form. The *inferior*, or *maxillary turbinated bone*, has many points in common with the last. It is, however, shorter and less bulky. It is attached by its inferior border to the crest on the superior maxillary bone, and is rolled from below upwards, being directly the reverse of the former, so that the two present the appearance of a bivalve shell. It has no connection with the ethmoid. The superior part of its cavity communicates with the maxillary sinus, the inferior with the middle meatus of the nose.

Use. Divide the nose into three meati. These bones seem destined to give a greater expansion to the pituitary mucous membrane, which covers their internal as well as their external surface. Of the meati into which they divide each nasal chamber, the superior is placed above the superior bone:—the median between the two bones, communicating with the internal cavities of each, and by a narrow opening with the maxillary sinus:—the inferior beneath the lower bone forms the floor of the nasal cavity. All three meati communicate anteriorly and also internally by an interval between them and the septum nasi.

Articulations. The *superior* articulates with the ethmoid, lachrymal, and nasal; the inferior with the superior maxillary.

Structure. They are composed of compact tissue throughout, but are exceedingly thin and fragile, traversed by minute grooves, and perforated by

Development.

foramina. They are each developed from a single centre of ossification, and are ossified to their supporting bones at different ages:—the superior during intra-uterine life; the inferior at about a year old.

Arrangement in the ox.

In sheep and goat.

Differences.—In the *ox*, the *superior turbinated bone* is small, and connected to the nasal by both its superior and its inferior border, so that it has no opening into the nasal cavity, but communicates throughout its entire extent with the maxillary sinus. The *inferior* is largely developed, attached to the superior maxillary bone by its middle part, and is rolled both upwards and downwards so that it opens into the lower, as well as the middle nasal meatus. Its cavity does not open into the maxillary sinus, which it closes very imperfectly. Behind its posterior extremity is a large opening, closed, however, in the fresh state by mucous membrane. It is later than in the horse in being ossified to the superior maxillary. In the *sheep* and *goat* the maxillary sinus is more completely closed by the turbinated bone than in the *ox*.

In the pig.

In the *pig* the bones are similar to those of the sheep, but are longer and less fragile.

In carnivora.

In *carnivora* the turbinated bones are remarkable for their numerous convolutions. They do not contribute to form the frontal or maxillary sinus. The last of these is at no part closed by the turbinated bone, but has a large gaping aperture.

INFERIOR MAXILLARY BONE.

Shape.

Mode of description.

Branches.

This bone (os maxillæ inferius) forms the basis of the lower jaw, and articulates with the temporal bone, by a diarthrodial joint. It is V-shaped, and its two branches (rami) are united together anteriorly, gradually diverge in a posterior direction, leaving an intervening triangular opening,—the intermaxillary space. The branches also increase in bulk from before backward. They are almost invariably ossified together previous to birth, but up to the last stages of intra-uterine life they are separated at the median line anteriorly, and as the two branches are symmetrical it will be more convenient to describe one only. Each branch possesses two surfaces, two borders, and two extremities.

Surfaces.

Inferior dental foramen.

The *external surface* is smooth and convex in its anterior half; and slightly rugose posteriorly, where it gives attachment to the masseter. The *internal surface* has its posterior half concave, and towards its supero-anterior part is a large foramen (inferior dental)

Labial foramen. **Ridge inside the alveoli.**

for the transmission of the dental nerve and artery. It is continued by a canal passing beside the roots of the molar teeth, sending a branch (labial) to the external surface, and losing itself in the anterior part of the bone. The anterior half is smooth and nearly flat, presents along the margin of the alveoli a slightly salient line, (the mylohyoidean ridge), and anteriorly a slight depression for the sublingual gland.

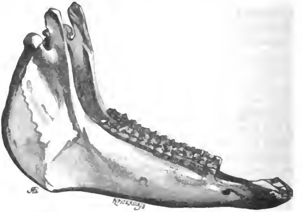

Fig. 95. Inferior Maxillary Bone.

Borders. **Superior has six cavities.** **Groove on the lower margin.**

The *superior* or *alveolar border* is composed of two parts: an anterior or horizontal part, and a posterior or vertical part. The former is straight, thick, and excavated into six alveoli for the reception of the molar teeth. The latter, separated from the alveolar by an obtuse angle, is concave, narrow, and roughened, giving attachment to the buccinator and depressor labii inferioris. The inferior border is also divided into an anterior straight and a posterior curved part. The former is thick, round, and smooth, in the young animal, getting thin and sharp in the old. Separating these parts is a slight groove, running obliquely from within outwards and forwards for the inferior maxillary artery. The posterior part is convex, thick and rugose, with a tuberous line at either side.

Extremities. Upper has a condyle and process.

The *posterior extremity* bears posteriorly an articular *condyle*, and anteriorly a flattened eminence called the *coronoid process*. The condyle is longest transversely. It is convex both in this and in its antero-posterior diameter. It articulates through the intervention of a fibro-cartilage with the articular surface on the zygoma. The coronoid process is flattened from side to side, and turns upwards, backwards, and slightly inwards. A deep notch between these two processes is called the sigmoid notch.

and notch.

Lower joins the anterior part.

The *inferior extremity* is flattened from above downward, and when united with the extremity of the opposite ramus, forms that part described in veterinary anatomy as the *body* of the bone. For the sake of convenience we shall describe the two extremities as such.

Body.

The *body* has two surfaces, a superior and inferior, and two borders, an anterior and posterior. The *superior surface* is smooth and concave, with a slight groove in the median line, a trace of the previous separation of the two branches. It is covered by buccal mucous membrane, and supports the free end of the tongue. The *inferior surface*, the larger of the two, is convex and continuous with the external surface of the branches. It presents a slight groove in the median line like that on the upper surface, and on each side a foramen (mental or labial), transmitting the terminal branch of the dental nerve and artery. On a level with this foramen is a constricted part of the bone called the neck. The *anterior border* is curved in the form of a parabola, and posteriorly on each side joining the superior border of the ramus. At its anterior part it is thick, and contains six alveoli for the insertion of the incisor teeth. In the case of tushes existing, two additional alveoli are found. Posteriorly to this it is sharp, forming the part generally known as the bars. The *posterior border* bounds the intermaxillary space anteriorly; it has in the angle a minute notch, and laterally two small roughened eminences, for the insertion of the genio-hyoideus.

Labial foramen.

Bars.

Structure.

Like other large bones, this is made up of cancellated tissue, enclosed between two compact plates.

Development.

According to some, this bone has only two centres of ossification, one for each ramus, while others mention several additional. While further investigation is required, the matter is difficult to decide in consequence of the early stage of its ossification.

Is smaller in the ox.

Differences.—In *ruminants* the bone is relatively smaller, the inferior border is convex, the condyles are small, concave laterally, and convex from before backwards, and the coronoid process turned backwards and outwards. The body contains eight alveoli for the incisors,

Body has eight alveoli.

but none for the tushes. The two lateral branches of the bone are never ossified together even in old animals.

Is short in the pig.

In the *pig* the inferior maxillary is proportionately shorter; the molars are placed towards the inner side of the superior border; there exists no neck; the interdental space is very restricted; the dental canal opens by several foramina inferiorly; and the body terminates in a point anteriorly. The condyle is compressed laterally and elongated antero-posteriorly. The coronoid process is broad, short, and turned backwards.

Pointed in front. Condyle narrow.

In dog and cat is small.

In *carnivora* the inferior maxillary is smaller but much thicker than in the other domestic animals. Postero-externally is a deep concavity for the masseter. The inferior border, curved like in ruminants, has just beneath the condyle a process for muscular insertion. The condyle is ovoid, corresponding exactly to the articular surface on the zygoma. The coronoid process is very largely developed, and turned backward and outward. Each lateral part contains, in the *dog*, eleven teeth, three incisors, a tush, and seven molars; in the *cat* seven only, three incisors, a tush, and three molars. The branches are never united by ossification.

Condyle ovoid.

OS HYOIDES.

Why named. Position.

The hyoid bone, so named from its likeness to the Greek letter *υ*, is situated between the branches of the inferior maxillary, in a direction from above downwards and forwards, being attached superiorly to the hyoid process of the temporal, and giving support inferiorly to the tongue, the larynx, and the pharynx. From its supporting the tongue it has also been called the lingual bone.

Formed of five pieces.

It consists of five pieces, a central part or *body*, and two lateral parts on either side, the horns (cornua). These remain distinct in the full-grown animal, but are generally considered as forming a single bone.

Body.

Body.—This has been happily likened by Percival to a spur, having the semicircular portion opening posteriorly, and from the middle of its convex border a straight projection (appendix) corresponding to the neck of the spur. Its median curved part is flattened from above downwards, and presents, superiorly, a smooth surface, bounded on either side by a rounded diarthrodial eminence for articulation with the lesser horn; inferiorly a flat, but roughened surface, for muscular attachment. The two lateral prolongations are flattened from side to side, and embrace the thyroid cartilage of the larynx, with which they articulate by their extremities through the medium of a fibro-cartilage. The appendix is irregularly prismatical, and roughened on all sides for the attachment of the lingual muscles. The body contains much spongy tissue, and is developed from three centres of ossification, one for the appendix, and one for each of the lateral branches.

Structure of the body. **Development.**

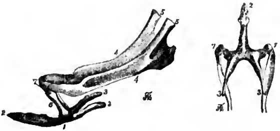

Fig. 96. Fig. 97.

Fig. 96. Side view of Os Hyoides, with its Cornu. Fig. 97. View of inferior surface of Hyoid Bone. 1 1, Body; 2 2, Spur process; 3 3 3 3, Branches; 4 4, Large cornua; 5 5, Superior extremities of large cornua, which join hyoid process of petrous temporal bone; 6, Lesser cornu; 7 7 7, Articulations between larger and lesser cornua; 8, Articulation between lesser cornu and body of os hyoides.

Small cornua.

Lesser Horns.—Each of these, about an inch and a half long, is directed from behind upwards, forwards, and outwards, is flat above, convex below; has a glenoid cavity at its inferior extremity for articulation with the body, and an oval superior extremity united by fibro-cartilage with the larger cornu. They are very spongy, and have each two centres of ossification, one being for the lower epiphysis.

Large cornua. **Surfaces.** **Borders.** **Tubercle on the lower border.** **Complimentary ossicles.**

Greater Horns.—These are long, flat pieces; directed from below backwards and upwards, flattened from side to side, and presenting each two surfaces, two borders, and two extremities. The internal surface is convex in both senses, the external correspondingly concave. Both are nearly smooth. The superior border is sharp anteriorly, concave and more rounded in its posterior half, by which it gives attachment to a yellow elastic band going to the pterygoid process. The inferior border is composed of two parts, an anterior straight, and a posterior very much smaller, and divided from the former by a rugose tubercle. This prominence forms a guide in puncturing the guttural pouches. Its inferior extremity joins the lesser horn at a right angle, articulating by a fibro-cartilage already mentioned. In the substance of this cartilage a small ovoid bony mass is frequently met with, supposed to represent the rudiment of a third pair of horns. The superior extremity, which is slightly tuberous, joins the hyoid process of the temporal by means of a cylindrical fibro-cartilage.

Structure, &c.

These cornua are almost entirely compact, and have each a single centre of ossification.

Ox has two more cornua.

Differences.—In *ruminants* there is an additional small cornu on each side, so that the bone is composed of seven pieces. The appendix is short and mammilated.

Pig has no appendix.

In the *pig* the body is large and deprived of the appendix, but has laterally a projection on each side corresponding to the small horn. The great horns are very thin, shaped like the letter S, and articulate with the temporals and the processes on the body by ligaments of yellow elastic tissue.

Carnivora have the body formed of three separate parts.

In the *dog* and *cat*, the three parts composing the body of the hyoid remain, like in man, without being united; the bone is, in consequence, composed of nine pieces. The cartilages uniting the lesser and greater branches together, and these last to the temporal, are longer than in most other animals. The median part of the body has no appendix.

THE SUTURES.

Rough on inner aspect, smooth without.

Division.

The bones of the cranium and face are joined to each other by sutures. These are often irregular (serrated or dentated) on their external margin, while their external plates are, as a general rule, smooth, and placed in simple apposition. The *cranial sutures* may be divided into three sets: the superior, the lateral, and the inferior.

The superior set.

Those on the vertix of the cranium are three; the parieto-frontal, the parieto-occipital, and the interparietal.

Fronto-parietal.

The serrations are deepest laterally.

The *fronto-parietal,* called also the *coronal,* from its occupying, in man, the part where the ancients wore their garlands, connects the frontal and parietal bones. It commences just behind and below the orbital process, and proceeds obliquely upwards and backwards to the vertix. The serrations are deepest at the lateral parts at which the parietal overlies the frontal; toward the vertix this order is reversed, the frontal overlying the parietal.

Occipito-parietal.

The *occipito-parietal,* called also the *lambdoid suture,* from its likeness to the Greek letter *Λ*, unites the parietal and occipital bones. It runs from the supero-posterior angle of the temporal bone upward and forward to the median line. Its dentations are very deep, and it

Deep serrations.

is perhaps the most frequent situation of Wormian bones, or ossa triqnetra.

Inter-parietal.

The *interparietal* or *sagittal suture*, (sagitta, an arrow), extends back in the median line from the middle of the coronal suture to the superior angle of the occipital. In the young animal this suture extends down in the median line of the facial bones as well.

The lateral set.

On the side of the cranium are the fronto-sphenoidal, the squamous, and the masto-occipital. These may be looked upon as simply divisions of a single suture, which runs along the whole of the lateral parts of the cranium.

Fronto-sphenoidal,

bevelled and morticed.

The *fronto-sphenoidal*, forming the union between the lateral ala of the sphenoid and the frontal bone, is the most anterior. The bones unite by smooth bevelled surfaces, with irregular margins. The superior margin of the ala is received between the plates of the frontal.

Squamo-parietal.

The *squamous*, or *squamo-parietal*, is arched upward. It is formed by the squamous part of the temporal overlapping the lower border of the parietal.

Masto-occipital.

The *masto-occipital*, between the mastoid part of the temporal and the occipital bones, has been considered as an appendix to the lambdoidal (additamentum suturæ lambdoidalis). It is formed by the simple apposition of the two flat surfaces of the bones.

The inferior set.

Basilar.

On the inferior surface of the cranium, the principal suture is the *basilar*. This is formed by the junction of the body of the occipital with that of the sphenoid bone. In the young animal, these bones are divided by a cartilage, but in the old are inseparably united. Others of less importance have been noticed, as a petro-sphenoidal and a squamo-sphenoidal, existing between these several bones.

Sutures of the face.

Transverse.

The bones of the face are also divided by well-marked sutures, but with a single exception, none of these have received definite names. The exception referred to is the *transverse*, which proceeds laterally from the median line, plunges into and traverses the orbit. It connects the frontal with the nasal, lacrymal, superior maxillary, and the sphenoid.

Use.

The evident use of the sutures is to allow the increase of the bones of the skull by growth from their margin. They likewise prevent the dispersion of shocks from blows upon that region.

GENERAL CONFORMATION OF THE SKULL.

That great, solid, bony mass, entering into the formation of the

Is pyramidal.
Division.
Superior surface.
Parietal crests.
Greatest breadth, where?

cranium and face, forms an osseous pyramid with its base posteriorly, its apex anteriorly, and hollowed out into various cavities or chambers. Externally it presents four surfaces, a base, and an apex. The *superior surface* is formed chiefly by the parietal, frontal, and nasal bones. It is bounded posteriorly by the occipital crest, from the middle of which runs a line, soon diverging into two lateral crests (parietal crests), and limiting the temporal fossæ superiorly. It attains its greatest breadth at the middle of the frontal bone, and from this it gradually diminishes to the extremity of the nasal bone, which is pointed. It always bends downwards at its posterior part, but below this straightens, and breadth of outline is justly esteemed.

Inferior surface.

On the *inferior surface*, we find in the median line, posteriorly, the basilar process of the occiput; laterally, at its posterior part, the condyloid foramina for the lingual nerve; anteriorly to each foramen, the foramen lacerum basis cranii; laterally, the petrous portion of the temporal bone, with its mastoid and styloid processes and foramina, together with its hyoid process. In front of the basilar process is the inter-maxillary space, in which is found the body of the sphenoid, having laterally the vidian fissure and foramen; more laterally, on the alæ, the grooves for the carotid artery and superior maxillary nerve, and in front of these is an eminence curved outward, formed by the pterygoid process, the pterygoid and the palatine bones, and pierced at its base by the infra-sphenoidal foramen. Before these is a large oval aperture, divided into two by the vomer, and constituting the posterior nares. Still more anteriorly is a smooth bony plate, forming the roof of the palate, having toward its lateral part, posteriorly, the palatine foramen, and continuous with this a groove for the palatine artery. This surface is bounded laterally by the rami of the lower jaw.

Lateral surface.
The orbit.

Each *lateral surface* presents, anteriorly, a triangular space, bearing some concavities and convexities, with the infra-orbital foramen in its middle part; posteriorly, the maxillary spine and the zygomatic arch, continuous with each other; also the orbit, and the temporal fossa. The orbit is a conical cavity, separated from the temporal fossa posteriorly by a fibrous sheath, and not by bone as in man and the quadrumana. Its opening is oval, the margins being formed by the frontal, the squamous portion of the temporal, the malar, and the lachrymal; its cavity is formed also by these, and, in addition, by the superior maxillary, the palatine, and the alæ of the

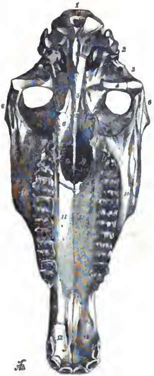

Fig. 98.

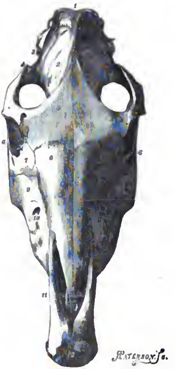

Fig 99.

Fig. 98. 1, Occiput. 2, Petrous portion, and 3, Squamous portion of temporal bone; 4, Condyle of the temporal bone; 5, Sphenoid; 6, Malar bone; 7, Vomer; 8, Palatine bone; 9 9, Posterior nares, separated by the vomer and bounded anteriorly by the anterior portions of the palatine bones; 10 10, Superior maxillary bones; 11 11, Palatine process of superior maxillary bones constituting the roof of the mouth; 12 12, Anterior maxillary bones.

Fig. 99. 1, Occipital crest; 2, Parietal; 3, Petrous portion of the temporal bone; 4 Zygomatic process of squamous temporal bone; 5, Frontal bone; 6 6, Malar bones; 7, Lachrymal bone; 8, Nasal bone; 9, Superior maxillary bone; 10, Infra-orbital foramen; 11, Anterior maxillary bone; 12, Foramen incisivum superior.

sphenoid. Superiorly, it is pierced by the supra-orbital foramen, and beneath this shows the depression for the tendon of the superior oblique, and the internal orbital foramen. Inferiorly is the superior maxillary hiatus, leading to three foramina, the lateral nasal, the palatine, and the superior dental; anteriorly is the lachrymal foramen; posteriorly is a concavity for the lachrymal gland; and at its depth the orbital hiatus, containing the optic, pathetic, lacerated, and round foramina. This cavity contains the eye with its muscles, the membrana nictitans, the lachrymal gland, and a quantity of fat, besides some vascular and nervous trunks.

The temporal fossa.

The *temporal fossa*, situated immediately behind the orbit, is bounded anteriorly by the orbital process of the frontal, externally and posteriorly by the zygomatic arch and temporal crest, and internally by the parietal crest. It contains inferiorly many foramina penetrating the parieto-temporal canal, and lodges throughout its entire extent the temporal muscle. Below all these are the branches of the lower jaw.

Base.

The *base* or *posterior part of the head* presents, superiorly, (*a*) the occipital crest, (*b*) below this the cervical tuberosity, (*c*) still lower the foramen magnum, (*d*) laterally two condyles, (*e*) more laterally the styloid processes, and in the interval between the two last the condyloid notches. More forward and inferiorly are the curved borders of the lower jaw.

Apex.

The *apex* is formed by the inferior and anterior maxillary bones, supports the incisor teeth, and is more or less rounded, according to the youth of the animal. Superiorly to these is a large opening, bounded superiorly by the nasal spine, divided in the fresh state by a cartilaginous septum, and constituting the anterior nares.

Internal cavities.

The skull contains internally, the *cranial cavity*, the *nasal fossæ*, and the *sinuses*, which are simply appendages of those last named.

Cranial cavity.

The *cranial cavity*, occupying the posterior part of the skull, is marked by numerous impressiones digitatæ and various processes. It is divided into two parts by the occipital protuberance and two lateral crests (parieto-temporal) continuous with that elevation, which bear on their summit a small groove for a meningeal artery.

Anterior part.

The *anterior cavity* is destined to lodge that part of the encephalic nervous mass, known as the cerebrum. It presents *superiorly* a simple vaulted roof with numerous digitated impressions and vascular grooves; in the median line a groove with two roughened borders, corresponding to the longitudinal sinus; this is limited anteriorly by the crista galli, and posteriorly by the occipital protuberance. The *inferior part* or *base* is bounded posteriorly by the basilar suture, and is about a third shorter than the superior. Examined from before backwards, the following objects are presented: (*a*) in the median line the crista galli, having on each side a deep fossa for the reception of the olfactory lobes, and bounded anteriorly by the cribriform plates for transmitting the olfactory nerves:—(*b*) next a quadrangular flat surface, and on a lower plane posteriorly a second (processus olivarius) at the antero-lateral parts of which are the optic foramina, giving passage to the optic nerves: (*c*) more posteriorly is a median depression (sella Turcica) for the reception of the pituitary body, and on each side of this a depression for the sphenoidal sinus; still more laterally is the sphenoidal hiatus, bounded externally by two ridges continuous with the parieto-temporal crests, and leading to the foramen rotundum, foramen lacerum orbitale, and foramen patheticum: (*d*) outside this hiatus is a concavity of some depth for cerebral convolutions.

Posterior part. The *posterior cavity*, much less than the anterior, contains the cerebellum, the pons varolii, and the medulla oblongata. *Superiorly*, it bears digital impressions, and exhibits a central and two lateral concavities for the reception of the corresponding lobes of the cerebellum; behind and at the lateral parts of the occipital protuberance are the superior openings of the parieto-temporal canal. The *base* of this cavity extends from the prominence at the union of the sphenoid and occipital anteriorly, to the foramen magnum posteriorly. It presents, in the median line, a transverse concavity for lodging the pons varolii, and behind this a large groove supporting the medulla oblongata. Laterally is the foramen lacerum basis cranii, bounded externally by the petrous portion of the temporal bone, which bears digital impressions, and has in its middle the internal auditory meatus; behind the lacerated is the condyloid foramen.

The nasal fossæ. The *nasal fossæ* are two lateral cavities, separated by a vertical, cartilaginous septum, and occupying the median part of the face. They open anteriorly and posteriorly by two large apertures, the anterior and posterior nares—the former being external, the latter opening into the pharynx. They have four walls—a superior, an inferior, an internal, and an external. **The roof.** The *roof*, formed by the nasal and frontal bones, is smooth and transversely concave, extending from the anterior nares to the cribriform plates of the ethmoid. **The floor.** The *floor*, formed by the superior and anterior maxillary, and the palatine bones,

The internal wall. **The external wall.**

enters into the formation of the inferior meatus, and, like the roof, is smooth and concave from side to side, extending from the anterior maxillary to the posterior border of the palatine bones. The *internal wall*, smooth and vertical, is formed by the vomer, the perpendicular plate of the ethmoid, and the cartilaginous septum. The *external wall*, vertically placed, but exceedingly irregular in form, is formed by the superior and inferior maxillary, the palatine and the turbinated bones, and the ethmoid cells. It presents above the superior meatus, the posterior part of which is turned downwards, forming the extremity of the nasal fossa; below this, the superior turbinated bones; still more inferiorly the middle meatus, in the posterior part of which is a very narrow, semicircular opening, communicating through the maxillary with all the sinuses on that side; more anteriorly are two elongated apertures, a superior and an inferior, by which the lower part of the turbinated bones communicates with this meatus; next in a downward direction is met the inferior turbinated bone, dividing the middle and inferior meatus, and, lastly, the smooth external wall of the last of these spaces. See Fig. 81, page 130.

The sinuses. **Position.** **Three in adult.**

The *sinuses* are anfractuous cavities, between the internal and external plates of the bones, communicating freely with each other and with the nasal fossæ, of which cavities they may be considered extensions. In the full-grown animal, three of these cavities exist on either side—the frontal, the maxillary, and the sphenoid.

The frontal.

The *frontal sinus*, formed by the concurrence of the frontal, nasal, superior, turbinated, and ethmoid bones, extends from behind the level of the orbital processes forward into the posterior part of the nasal bones. It is deepest near the median line, about an inch in front of a line drawn between the supra-orbital foramina; this is from the internal plate, projecting downwards, at this point to form the anterior wall of the cranial cavity. A bony septum separates this from the sinus on the opposite side. Its inferior extremity has sometimes been called the *nasal* sinus.

The maxillary.

The *maxillary sinus*, the largest of the three, is formed posteriorly by the lachrymal and malar; anteriorly and externally by the superior maxillary; internally by the lower turbinated bone and the ethmoid cells. It is very diverticulated, one transverse plate, especially, on a level with the space between the second and third-last molars, generally remains complete throughout life, though it is sometimes reduced to two mucous membranes, placed together back to back. This divides the sinus into two great cavities, called by

Chauveau the *superior* and *inferior* maxillary sinuses. The superior part communicates freely with the posterior part of the lower turbinated bone, as well as with the middle meatus. The anterior opens separately into the middle meatus by the anterior part of the common aperture. They are each divided into an internal and an external part by a ridge, which runs from behind forwards, and which contains internally the superior dental canal. On the floor of the anterior is an elevation, caused by the root of the fourth molar tooth, in that of the posterior two caused by the fifth and sixth. It communicates internally with the middle meatus of the nose, posteriorly by a large opening with the frontal, while its external division is continuous inferiorly with the sphenoidal. Frequently, too, it opens into the superior, or largest of the ethmoid cells, the cavity of which is described by Chauveau as the *ethmoid sinus*. The sinus, considered as a whole, extends forward to the third molar tooth, and backward into the alveolar tuberosity. An opening made an inch above the maxillary spine, at its median part, opens into the mass of the cavity.

Sphenoidal sinus.

Sphenoidal sinus.—This is the smallest of the three, and is formed by the sphenoid and palatine bones. It is partially divided by several projections, especially by an imperfect division between its sphenoidal and palatine part. It is separated from its fellow on the opposite side by a thin lamina, which becomes perforated at an early age.

Development.

Development of the sinuses.—At one stage of fœtal life, no sinuses exist, but before birth they have been developed to some extent, and their size increases with the age of the animal. The frontal is first formed, after that the sphenoidal, and lastly the maxillary, the inferior part of which only begins to form about the age of six months.—(GOUBEAUX). They are all covered by mucous membrane, continuous with that of the nose, but much reduced in thickness, much less vascular, and applied directly upon the bone. They do not seem to fulfil any purpose connected either with respiration or the sense of smell; their great, if not sole, use appears to be the preservation of the bulk and symmetry of the head, without in any degree adding to its density.

In the ox are larger.

Differences.—In the *ox* the frontal is much more capacious, extending into the osseous basis of the horns, into the parietal and occipital, and covers the whole posterior and superior aspects of the cranium, so that the brain is here protected by two strong plates, united at different parts by irregular laminæ. Rigot says that in the young animal it is divided into five principal compartments, four of which open under the most superior of the ethmoid cells, the last opening under the base of the lower turbinated bone. None of these communicate with the maxillary sinus, but extend to the small sphenoidal. The maxillary is not divided, as in solipedes, into an interior and posterior compartment; it extends between the plates of the palatine arch, and communicates by a large opening with the middle meatus.

Sheep and goat.

In the *sheep* and *goat* the sinuses have a similar conformation to those of the ox, but are less extended. The frontal does not extend into the parietal.

In the pig.

In the *pig* their arrangement and extent do not materially differ from that of the sheep, The frontal, however, has an extension between the plates of the parietal.

In carnivora.

In the *dog* and *cat* no sphenoidal sinus exists; the maxillary is small; the frontal is better developed, and opens into the nasal cavity by a small opening near the median line.

THE HEAD CONSIDERED AS VERTEBRAL SEGMENTS.

It only remains for us now to consider the skull, according to the laws of homology, to enumerate the different segments and point out the bones composing their various parts. In doing so, the conclusions of Professor Owen are adopted.

Number.

We can trace the various parts composing the vertebral segments in the head with nearly as much certainty as in the dorsal region. The centrum, as in the last-named portion, is found occupying a median position, while above we can find, in a more or less modified form, the representative of the neural arch, and inferiorly—it may be even more modified—that of the hæmal arch. The different segments are enumerated by Owen as follows:—*occipital*, *parietal*, *frontal*, and *nasal*. Each of these will be examined in the order enumerated.

Occipital.

The shoulder blade its hæmopophysis.

Occipital vertebra.—In this segment the basilar process represents the centrum, the foramen magnum—the neural ring, and the superior plates of the bone—the neurapophyses and neural spine. The condyles correspond to the articular processes (zyapophyses), and the styloid processes to the transverse (diapophyses). The hæmal arch, at first sight, seems wanting, but it has been found that the scapula, or first bone of the fore-limb, is in reality this part somewhat modified in position and form to enable it to fulfil the function assigned it. This is proved beyond doubt by the fact that the pectoral fins of fishes, the true homologue of the human arms, and the fore-limbs of other mammals, are attached to the occipital bone.

Parietal.

Parietal vertebra.—The centrum of this segment is the posterior division of the body of the sphenoid bone; the posterior alæ of the same bone form its neurapophyses, and the parietal bones its neural spine. These together form an enormous neural ring, varying in size with the dimensions of the cranial cavity. The hæmal arch is very rudimentary, being represented by the hyoid bone. The cornua, in this case, correspond to the pleurapophyses, and hæmapophyses, while the body represents the hæmal spine.

Hyoid bone is the hæmal arch.

Every one must be struck by the marked contrast exhibited between this and a vertebral segment from the dorsal region. The incomplete and fragile hæmal arch differs widely from the well-developed rib and sternum, while, on the other hand, the enormous plates enclosing the cranial cavity shows a variation little less remarkable, from the constricted neural arch of that part.

Frontal.

Frontal vertebra.—This segment, placed between the cranium and face, has the anterior segment of the body of the sphenoid for its centrum, its anterior alæ for its neurapophyses, and the frontal for its neural spine. The hæmal arch is more developed in this segment than in the parietal, the pleurapophyses being represented by the squamous portion of the temporal bone, and the hæmapophyses and hæmal spine by the inferior maxillary. This last portion is considerably altered, to serve as an organ of mastication.

Lower jaw is the hæmal arch.

Nasal.

Nasal vertebra.—The divisions of this segment are, perhaps, somewhat obscure. Its centrum, the vomer, is enormously elongated in the lower animals, and flattened from side to side, constituting the basis of the nasal septum. The neurapophyses, blended together in this case, are represented by the perpendicular plate of the ethmoid, while the neural spine formed by the nasal bones is much elongated, and projects anteriorly to close the superior part of the nasal fossæ. The hæmal arch is made up of the palatine, and the maxillary bones of the upper jaw, the former being the pleurapophyses and the latter, the hæmapophyses and hæmal spine.

Hæmal arch is upper jaw.

In this vertebra it will be observed that no neural arch exists, and at the same time the hæmal arch has undergone extraordinary modifications, to fit it for its peculiar situation and functions.

This view of these different parts is not devoid of interest, showing as it does the preservation of the different segments in their integrity, so far as the primitive vertebral type is concerned, co-ordinate with the most extreme modifications in the different parts, as their position may call for a variation in their functions. Thus, in the three last, in which the brain is to be protected, the neural arches are developed out of all proportion to its size in other regions; while in the anterior segment, in which no neural arch is wanted, the neurapophyses are represented by a single delicate plate, dividing the nasal cavity posteriorly; on the other hand, the remarkable development of the neural spine in this segment shows, so to speak, the great elasticity of the type, and its remarkable power of adaptation. The modifications in the hæmal arches are no less remarkable. The hæmapophyses of the occipital, removed to the sides of the chest, flattened out and otherwise modified for the suspension of the body between them, might possibly never have been awarded their true places, had not the pectoral fins of the fish furnished the connecting links in the chain of modifications, and given a true direction to the investigations of the comparative anatomist. Again, as regards the three first segments the weak bony elements of the hyoid present a striking contrast to the bulky and powerful masses composing the jaws, which, with the teeth they contain, are so admirably fitted for seizing and masticating those aliments upon which the animal subsists.

THE THORAX.

Form. **Position.** **Use.** **Its parts.**

The thorax or chest is a vast conical cavity with its apex anteriorly, and its base postero-inferiorly, occupying the median part of the body, being separated from the head by the cervical, and from the pelvis by the lumbar regions. It is a great visceral cavity bounded by osseous and cartilaginous walls, and destined to enclose and protect the central organs of circulation and respiration. In the horse it is composed:—superiorly of the eighteen dorsal vertebræ already described,—inferiorly of a single bone, the sternum,—and laterally of thirty-six ribs, eighteen on each side, together with the cartilages of prolongation. These are in reality all portions of the corresponding vertebral segments, the superior parts being the centrum and neural arch; the lateral part, the pleurapophysis and hæmapophysis; and the inferior part, the hæmal spine. The dorsal vertebræ having been already described, the sternum and ribs will now be successively disposed of.

THE STERNUM, WITH ITS CARTILAGES.

Made up of hæmal spines.

The sternum or breast-bone (os pectoris) is, as we have seen, simply a confluence of several hæmal spines to form a single mass. It is a

Position. Form. Mode of description.

great osseo-cartilaginous mass, situated in the antero-inferior part of the thorax, in the median line, directed from above downward and backward, and forming the keystone, as it were, of the inverted arch. It is slightly curved, presenting its convexity inferiorly, is flattened from side to side in its anterior two-thirds, from above downwards in the posterior third, and presents for consideration three surfaces—a *superior* and *two lateral*, three borders—an *inferior* and two *lateral*, and two extremities—an *anterior* and a *posterior.*

Surfaces. Superior.

The *superior surface* slightly concave in an antero-posterior direction, is in the form of an isoceles triangle with its base posteriorly. It is nearly smooth, forms the floor of the thoracic cavity, and gives attachment to the pericardium and the *sterno-costales muscle.* Each *lateral surface* is divided into a superior and inferior portion. The superior part bears eight articular depressions for the reception of the cartilages of the ribs. These, like the articulations for the head of the ribs, are each formed of two facets united at an acute angle; they gradually diminish from before backwards. They are separated by prominent intervals, to which the intercostals are attached, and these, too, decrease from first to last. The inferior part, somewhat rough, affords attachment to the pectoral muscles.

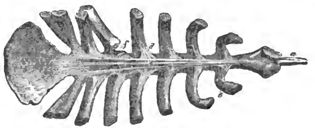

Fig. 100.—*a*, Cariniform cartilage; *b*, Ensiform cartilage; *c*, The upper sternal ligament; *f* and *d*, Showing connection of costal cartilages with sternum; *e*, Indicates the connection between a rib and its costal cartilage.

Lateral. Has eight articular cavities.

Borders.

The *two lateral borders*, diverging from the median line in front, run along above the articular cavities, and give insertion to sterno-costal ligaments. The *inferior border* is convex, and resembles to some extent the keel of a ship; it is very thin and salient in its anterior two-thirds.

Extremities. Cariniform cartilage.

The *two extremities* are terminated by cartilages. The anterior curved from below upwards, flattened laterally, and having a thin anterior border, is known as the *cariniform cartilage.* It gives

Ensiform cartilage.

attachment to the sterno-maxillaris, sterno thyro-hyoideus, and levator humeri. The *posterior* flattened from above downward, very thin, concave superiorly, convex inferiorly, and rounded posteriorly, is the *ensiform cartilage*. It gives attachment to the linea alba and abdominal muscles, while it supports superiorly the transverse colon.

Structure.

Development.

The sternum is formed of six bony masses, arranged in a line, and imbedded in the original cartilaginous matrix. These increase in size with advancing age, but are never ossified together in solipedes. The three first are elipsoidal, the three following prismatical, and the last flattened from above downward. The bony pieces are extremely spongy, so that the mass is comparatively light.

In ox is flat.

No cariniform cartilage.

Small ensiform cartilage.

Seven pieces.

Diarthrodial joint between two first.

Sheep and goat have no joint.

Development.

DIFFERENCES. *Ruminants.* — In the *ox* the sternum, with the exception of the first bone, is flattened from above downwards, and presents two tolerably smooth surfaces, the inferior of which is covered in the fresh specimen by a great fibrous and fatty pad:—two lateral borders bearing the cavities for the articulation of the costal cartilages:—an anterior extremity, simply rounded, and without a cariniform cartilage:—and a posterior extremity, bearing a small ensiform cartilage, into which projects a long bony pedicle from the last segment of the sternum. It consists of seven bony segments, of which all but the first are early united by ossification. Between the first and second there exists, throughout life, a diarthrodial joint permitting lateral movement. In the *sheep* and *goat* the first and second pieces are united immoveably by cartilage. In other respects it resembles that of the ox. All ruminants have each segment developed from two lateral centres.

In the pig is flat, with joint; six pieces.

Pig.—The sternum of the pig is flattened from above downwards, and has a diarthrodial joint between the two first pieces, exactly like that of the ox. It is made up of six segments, the last four or five of which are composed of two lateral pieces. Anteriorly is a cariniform cartilage.

In carnivora have eight pieces.

In the *dog* and *cat* the sternum is composed of eight pieces, constricted at their middle, and bulging at their extremities, so as to resemble somewhat the last coccygeal vertebræ of the horse. The pieces never become ossified together. From the anterior part projects a cariniform cartilage.

THE RIBS AND THEIR CARTILAGES.

Position.

The ribs (costæ), forming the lateral parts of the thorax, articulate above with the vertebræ, while, inferiorly, they join the sternum by cartilaginous prolongations. Eighteen exist on either side, running Number. nearly in parallel lines, and leaving intervening intervals called the intercostal spaces. Eight of these join the sternum directly by means

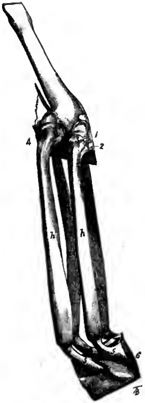

Fig. 101. Ribs. 1, Dorsal vertebra; *h h*, Fifth and sixth ribs; 2 2, Head of ribs; 3 3, Tubercle on head; 4, Angle of rib; 5, Costal cartilage; 6, Portion of sternum.

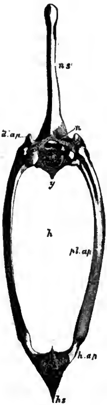

Fig. 102. Thoracic Segment. *c*, centrum; *n*, neural arch; *h*, hæmal arch; *n.s.*, neural spine; *h.s.*, hæmal spine; *d. ap.*, diapophysis; *h. ap.*, hæmapophysis; *y*, hypapophysis; *pl. ap.*, pleurapophysis.

of their cartilages, and are consequently called *true* or *sternal ribs*, True and false ribs. while the remaining ten have their cartilages simply attached to those in front of them, and join the sternum by this means; these, accordingly, are termed *false* or *asternal ribs*. They are also distinguished as *first*, *second*, and *third*, counting from before backwards. We shall consider first a rib from the middle of the thorax as a type, and then notice the differential characters of each.

Characters. A rib then represents an osseous arch, with its convexity turned outwards and backwards, and its concavity inwards and forwards; it is slightly twisted on itself, so that the two extremities will not both lie at once on a plain surface. Like all long bones this may be divided into a body and two extremities.

Body. Surfaces. Borders. The *body* is flattened from within outwards, and presents two surfaces and two borders. The *external surface*, generally smooth, is convex in its posterior, and concave in its anterior half, while superiorly are seen some roughnesses for muscular insertion. These asperities correspond to the angle of the human rib. The *internal surface* is smooth and concave, corresponding to the lung, and is covered by the external reflection of the pleura. The *anterior border* is concave, thin, and sharp, giving attachment to the internal intercostals. The *posterior border* is convex, thick, and rugose, giving attachment to the intercostals. Its superior half has on its inner aspect a groove lodging the intercostal vessels and nerves.

Extremities. Head and tubercle. Neck. Lower end. The *superior extremity* bears two projections by which it is attached to the vertebræ. These are placed one in front of the other, the anterior being the *head*, and the posterior the *tubercle*. The former has two articulating facets to articulate with the cavity formed by the union of the facets on the bodies of the vertebræ; between the facets is a notch for the insertion of the interarticular ligament. The latter, smaller than the head, is roughened, for muscular attachment, and on its internal aspect bears a facet for articulation with the transverse process of the posterior of the two vertebra with which the *head* articulates. Separating these two is a constricted part, called the *neck*, rugose above for the vertebro-costal ligament. The *inferior extremity* is enlarged and scooped out inferiorly into a cavity of greater or less depth for the reception of the costal cartilage.

Differences. Length. Breadth. Curvature. Their *differential characters* consist chiefly in the length, breadth, and degree of curvature. 1st, Their length increases gradually from the first to the ninth inclusively, and diminishes from that to the last. 2nd, Their breadth increases from the first to the sixth inclusively, and decreases constantly from that to the eighteenth. 3rd, The degree of curvature described by the ribs increases from the first to the last, and from the ninth backward the arches they describe correspond to circles gradually decreasing in size. The curve in the anterior ribs is almost entirely at the neck, while in the posterior it is throughout their entire extent. The concavity on the external surface is less marked where the rib is straight.

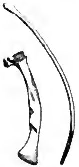
Fig. 103. Rib. Fig. 104. One of the last false ribs.

First rib short and straight.

The first rib is easily distinguished from the others; (*a*), by its shortness, its thickness, and its rectilinear direction; (*b*), by its having no groove on its external surface, which, however, bears asperities at its middle part for the insertion of the scalenus, and by a notch for the axillary artery; (*c*), by its having no groove on its posterior border; and (*d*), by its having no notch between the facets on its head, which only articulates with a single dorsal vertebra. The last rib has no groove on its external surface, and the facet on its tubercle is confounded with that on the head; this latter peculiarity is common also in the seventeenth.

Last rib has the tubercle confounded with the head.

Structure.

These bones contain much spongy tissue, except when they are much constricted, as in the superior half, where the compact tissue is increased to make up for their want of bulk. They are developed from three centres of ossification, one for the body and inferior extremity, one for the head, and one for the tubercle. In the one or two last ribs, the superior extremity is developed from a single centre, as the two parts composing it become confounded.

Ossification.

THE COSTAL CARTILAGES.

The costal cartilages, corresponding to the inferior ribs of birds, complete the lateral walls of the thorax inferiorly, and by virtue of their elasticity, add greatly to its mobility. They are small cylindrical cartilages, equal to the ribs in number, slightly compressed from within outwards, and smooth both on their surface and borders. Externally the sternal cartilages are covered by the pectoral muscles, and the asternal by the rectus and obliquus abdominis; internally they are related to the costo-sternal muscles, the diaphragm and transversalis abdominis; by their borders, which correspond to the intercostal spaces, they give attachment to muscles and aponeuroses corresponding to the intercostals. The superior extremity

One for each rib.

is the largest, and is received into the concavities on the lower extremity of the rib to which it belongs. At the inferior extremity, each of the first eight is elongated from above downwards, convex from before backwards and depressed in the centre; they are each fitted into an alveolus on the lateral border of the sternum, the union being effected through the medium of a fibro-cartilaginous disc. The last ten, the prolongations of the ten false ribs, are very slender, and terminate by blunt points, each united to the cartilage in front of it by a yellow elastic ligament.

The first eight articulate with the sternum.

The last ten articulate with one another.

Individual characters.

None of the cartilages of the true ribs unite directly with each other. The eighth is, for a considerable distance, in apposition to that of the first false rib, and through it those of all the false ribs are prolonged to the sternum, each being applied upon that in front of it, and connected by means of muscular and white fibrous tissue. They decrease in thickness from the first to the last. Their length increases from the first to the ninth inclusively, and from that to the last gradually decreases. The first is easily recognised by its shortness, its great thickness, and by a facet on its inner surface for articulation with the cartilage opposite.

Structure and development.

These bodies are completely cartilaginous in the young animal, but at an early age bony matter gets deposited in their centre, and in the fully-developed animal they are commonly spongy (bony) tissue, with large inter-spaces, and covered by a cartilaginous coating which remains throughout life.

DIFFERENCES PRESENTED BY THE RIBS AND THEIR CARTILAGES IN THE OTHER DOMESTIC ANIMALS.

Less curved in the ass.

The ox has thirteen ribs.

Longer and broader than horse's.

The true ribs join their cartilages by a diarthrodial joint. Sheep and goat have no such joint.

In the *ass* and *mule* the ribs, and more especially the posterior ones, are less curved than in the horse. The *ox* has on each side eight true and five false ribs, making thirteen in all. They are longer and broader than in the horse, their breadth being greatest and their curvature least in their inferior half. The head and tubercle are proportionately large, and are well detached from the rib; in the last, and sometimes in the twelfth as well, the tubercle is nearly absent, and bears an articulating facet. All the true ribs join their cartilages by a true diarthrodial joint. In the *sheep* and *goat* there is no diarthrodial joint between the ribs and their cartilages. The *pig* has fourteen ribs on each side, the first seven of which are sternal. They correspond in general form to those of the ox, but are unlike, as none unite with the cartilage by diarthrodial articulation. They are also slightly more curved than in the ox. In the last four the facet on the tuberosity is continuous with that on the head. The sternal ribs have large cartilages, flattened from side to side, with a convex and sharp anterior border.

Pig has fourteen like the ox's.

The *carnivora* have thirteen ribs on each side, nine sternal and four asternal. They are very thick and narrow, rather short, but possessing a great curvature, and have more of an angle than in the other domestic animals. In the *cat* the facet on the tubercle of the rib loses itself in that of the head in the three last, while in the *dog* it remains separate in all. The costal cartilages have little tendency to ossific deposit, and remain cartilaginous to a very advanced age.

Dog and cat have thirteen. Much curved.

Cartilages seldom ossify.

GENERAL FORM OF THE THORAX.

The conical form of the thorax is somewhat irregular, being imperfect and oval at the summit. This oval form anteriorly depends on its being flattened laterally, to allow such an attachment of the anterior extremities as shall be favourable to their uses as organs of support and locomotion. In the lower animals, accordingly, this cavity is much less in a transverse than in an antero-posterior direction, the slight mobility in the anterior part being compensated by the number and arrangement of the very mobile false ribs.* In noticing the external conformation of this part, there may be considered a *superior*, an *inferior*, and two *lateral planes*, together with a base and a summit.

Why flattened anteriorly.

Is longest in an antero-posterior direction.

The *superior aspect* is divided in the median line by the dorsal spines, which give rise to a large groove on each side, the vertebral, filled up by the great muscles of the back and loins. The *inferior*, convex from side to side, and having a sharp ridge in the median line anteriorly, presents at its extremities the projecting cartilages already mentioned, and on each side the costal cartilages with their articulations, costal and sternal. Each *lateral* plane is convex, most marked toward its base, covered antero-superiorly by the fore extremity, with its attaching muscles, and posteriorly by the external oblique of the abdomen.

External aspects. Superior.

Inferior aspect.

Lateral aspects.

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* In the quadrumana the thorax may be equal in its transverse to its antero-posterior diameter, this form being favourable to climbing habits, but the predominance of the former over the latter is always far short of that of the corresponding part in the human subject.

Base.

The *base* is formed by the posterior borders of the last rib and the cartilages of the false ribs; it is closed by the diaphragm, which is attached all round its circumference.

Summit.

The *summit* is formed by the two first ribs, with their intervening space, which is oval, and elongated vertically, giving passage to the longus colli, trachea, œsophagus, carotid arteries, jugular veins, vertebral arteries and veins, axillary arteries and veins, sympathetic, pneumogastric, recurrent and phrenic nerves, and the thoracic duct.

THE LIMBS.

Land mammals have four limbs.

Each limb has three elements attached to a hæmal arch.

Middle and distal element modified according to their use.

All terrestrial mammalia have two pairs of limbs. The anterior and posterior limbs are constructed on the same principle, being each attached to the hæmal arches of particular vertebræ, and composed of a proximal, a middle and a distal element. The *proximal* portion is that connected with the hæmal arch; the *distal* is the terminal part of the limb, and its construction is varied according as it is wanted for prehension, as in the hand of man; for support, as in the metacarpus of the horse; or for both these purposes, as in the same part in the cat; the *central* or *middle* portion consists of two segments variously modified according as they are required to perform the various functions of support, swimming, digging or prehension. This part always gives attachment to muscles connected with both the others.

In our domestic animals the shoulder represents the hæmal arch attaching the fore-limb, the arm its proximal, the fore-arm its central, and the foot its distal portion. The hind limb has its hæmal arch represented by the haunch-bones, its proximal element by the thigh, its central by the leg, and the distal by the foot.

FORE LIMBS.—THE SHOULDER.

Horse has a single bone as the basis of the shoulder.

Rudiment of clavicle in the cat and dog.

In the horse this part is composed of a single bone, the *scapula* or *blade-bone*. In its typical form, however, it is composed of three bones, the two additional ones being the clavicle (clavis, a key) and the coracoid (*κοραξ*, a crow*). These two last, when fully developed, as in birds, join each other in front either directly or through the medium of the sternum, thereby completing the arch. In the cat and dog we have a clavicle, not however immediately connected with the sternum or scapula. It is simply a more or less elongated osseous nucleus imbedded in a ligamentous cord.

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* From a fancied resemblance in the human subject to the beak of this creature.

THE SCAPULA.

Position. Direction. Form.

This bone is situated on the antero-lateral part of the thorax directed obliquely from above downward and forward, and partly covers the first six or seven ribs. It is a flattened and irregularly triangular bone, prolonged at its base by a large cartilaginous plate. It presents for examination two surfaces, three borders, and three angles.

Venter. Subscapular fossa.

The *inner surface*, called also *venter scapulæ*, presents a great depression (subscapular fossa), lodging the subscapularis muscle.

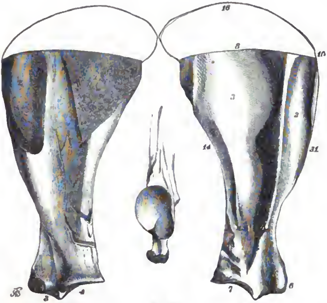

Fig. 105. Fig. 107. Fig. 106.

Scapula. Fig. 105.—1, Spine, angle for attachment of trapezius ; 2, Anterior spinous fossa ; 3, Posterior spinous fossa ; 4, Triangular surface at end of spine, over which trapezius glides ; 5, Acromian angle ; 6, Coracoid process ; 7, Glenoid cavity ; 8, Base ; 9, Neck ; 10, Superior angle ; 11, Posterior angle ; 12, Roughened surface for attachment of teres externus ; 13, Anterior margin ; 14, Posterior margin ; 15, Nutrient foramen ; 16, Cartilage of prolongation. Fig. 106.—1, Outer or subscapular fossa ; 2 2, Roughened triangular surfaces for attachment of serratus magnus ; 3, Beak-shaped end of coracoid process ; 4, Glenoid cavity. Fig. 107.—View of glenoid cavity, with notch on the inner and anterior part, and coracoid process in front.

Triangular spaces.

This fossa is prolonged in the median line to the superior margin of the bone, and separates two triangular spaces, which correspond to the two superior angles of the bone, and give attachment to the

Dorsum. Spine. Fossæ antea and postea spinata. Nutrient foramen. Tuberosity of the spine.

serratus magnus and rhomboidei muscles. The *outer surface (dorsum scapulæ)* is divided by a prominent ridge (spine) into two unequal parts. The portion in front of the spine, the narrower of the two, is smooth and concave, and is termed *fossa antea spina'a;* while that behind the spine is called *fossa postea spinata.* Both are occupied by muscles. On the *fossa postea spinata* are several linear roughnesses for muscular attachment, and toward the neck of the bone, its principal nutrient foramen. The spine stands out on the whole surface of the bone from its neck to its base. Toward its middle and most prominent part is a flattened elevation called the *tuberosity of the spine.* As there is no clavicle, the acromion process is not developed.

Borders.

The *superior border* or *base* is grooved for the reception of the cartilage. The *anterior* is thin and smooth, convex superiorly, concave inferiorly. The *pôsterior* is thick, smooth, slightly concave, and gives attachment to numerous muscles.

Angles. Neck.

The *antero-superior* or *cervical angle* is thin, and formed by the junction of the base with the anterior border. The *posterior* or *dorsal angle,* placed at the union of the base with the posterior border of the bone, is thick and rounded internally. The *inferior* or *humeral angle,* separated from the rest of the bone by a constricted part or *neck,* is largely expanded to form the articular cavity and coracoid process.

Glenoid cavity. Coracoid process.

The *articular surface* of the bone, called the glenoid (shallow) cavity is bounded by a sharp margin, to which is attached the capsular ligament of the shoulder-joint. It is of an oval form, with its greatest diameter directed from before backwards, and like all diarthrodial surfaces, is covered by articular cartilage. Internally it presents a notch for the passage of blood-vessels to the joint. In front of the cavity is a considerable tuberosity (coracoid process) slightly bent inwards at its extremity, and giving attachment to the tendons of origin of the coraco radialis and coraco humeralis muscles.

Structure. Development.

The scapula is formed of two compact plates, with intermediate cancellated tissue, existing in greatest relative amount on the posterior and inferior angles of the bone. Ossification proceeds from two centres, one for the body of the bone, and the other for the coracoid process.

Cartilage of prolongation.

Cartilage of the scapula.—Attached by its lower border to the base of the scapula, this cartilage gradually decreases in thickness to its fore margin, which is exceedingly thin and turned inward. This superior or unattached border is convex, and overlaps the posterior

Its use.

angle of the bone. The great development of this cartilaginous plate in the horse and in ruminants increases the surfaces for muscular attachment, while, by its flexibility, it tends to ward off concussion, and contributes to the elasticity of the muscular girdle by which the trunk is supported on the anterior extremities. In old horses it is always more or less ossified.

Ox.

Acromion process.

Differences.—The scapula of *ruminants* is broader and more regularly triangular than that of the horse. Its spine, instead of disappearing gradually toward the neck of the bone, as in the horse, detaches itself from the surface, and projects forward and outward into a point called the *acromion* (ἄκρος, summit; ὦμος, shoulder). The disproportion between the fossæ antea and postea spinata is much greater than in the horse, the former being no more than a third of the size of the latter. The inferior angle is also more detached from the bone.

Pig.

Posterior spine.

In the *pig* the tubercle on the spine of the scapula is developed into a great flattened projection (posterior spine), which is turned backwards so as to cover part of the fossa postea spinata. The acromion is not developed.

Dog.

Recurrent process.

In *carnivora* the scapula is broad, and the acromion better developed than in any other domestic animals, reaching to the level of the glenoid cavity. The spine is relatively more prominent than in other animals, and divides the dorsal surface of the bone into two fossæ of equal size. Toward its inferior fifth the fore margin of the spine is prolonged backward into a broad process, called by Strauss Durcheim the *recurrent process*, which gives attachment to the cervical trapezius and part of the mastoido humeralis.

Cat has great coracoid.

The coracoid process, so named from its resemblance to a crow's beak (κόραξ, crow; εἶδος, like), is well developed in the *cat*. It is bent inwards and downwards, giving attachment to the coraco brachialis, leaving between it and the edge of the glenoid cavity a notch for the tendon of the subscapularis.

No cartilage in carnivora.

The scapula in the carnivora has no cartilaginous prolongation.

Clavicle.

The clavicle in the *dog* is a very thin mass of bone buried among the muscles on the inner side of the shoulder-joint. In the cat it is a styloid mass, continued to the acromion and the sternum by ligamentous tissue.

Rodent.

In the *rabbit* the tubercle on the spine and the acromion are remarkably developed. The clavicle is larger than that of the cat, but does not come into direct contact with the sternum or acromion.

THE ARM (PROXIMAL ELEMENT).

The bony framework of the arm is made up of a single bone, the humerus (os humeri).

THE HUMERUS.

Position. Direction. This bone is placed on the side of the thorax, between the scapula and the bones of the fore-arm; it articulates with the former above, with the latter below. Its direction is from above downwards and backwards, the reverse of that of the scapula, with which it forms an angle, varying according to the movements of the limbs.

Fig. 108. Fig. 109. Fig. 110.

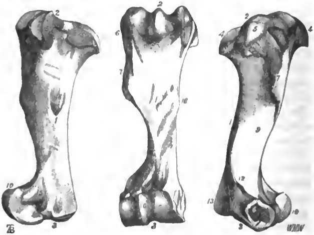

Fig. 108. Internal View; Fig. 109. Front View; and Fig. 110. External Aspect of Humerus. 1 1 1, Shaft; 2 2 2, Superior extremity; 3 3 3, Condyles; 4 4, Head; 5, Outer large tuberosity; 5 a, Inner small tuberosity; 6 6, Crest of the outer tuberosity; 7, Ridge descending from external tuberosity; 8, Trochlea; 9, Musculo-spiral groove; 10, Articular aspect of condyles; 11, Epitrochlea; 12, Crest of epitrochlea; Between 11 and 13, is the epitrochlean fossa; 13, Epicondyle; 14, Fossa for insertion of external lateral ligament of elbow-joint; 15, Fossa for internal lateral ligament; 16, Asperity for muscular insertion.

Form. It is a long bone, twisted into the shape of the letter S, and divisible into a shaft and two extremities. The shaft presents three borders and three surfaces for examination.

Surfaces. Musculo-spiral groove. On the *external surface* we find one of the most characteristic features of the humerus, the *musculo-spiral groove,* which winds round the outside of the bone from the posterior aspect of the head, down to the coronoid fossa in front. It is occupied by the ***humeralis*** *externus*—the margin dividing this from the anterior border is well marked. It runs from above the coronoid fossa in front upwards and outwards to the external aspect of the bone, to terminate in the external tuberosity of the body of the humerus (deltoid ridge in man), which last affords attachment to the teres externus. **External tuberosity.** This tuberosity is very prominent, flattened from before backwards, and turned backwards so as to contribute to the formation of the spiral groove. It is prolonged superiorly by two curved lines, of which the anterior, the most prominent, is extended upwards to the external tubercle, the posterior is curved backwards to the base of the head. The border which separates the spiral groove from the posterior surface is a well marked ridge in its inferior half; this from its being situated above the trochlea has been called the *epitrochlean crest*; **Epitrochlean crest.** the superior half is only represented by a spiral line leading upwards to the external aspect of the head. The anterior surface, much broader superiorly than inferiorly, presents at its median part some asperities for the insertion of the coraco humeralis. The *internal surface*, rounded from side to side, merges into the anterior and posterior aspects of the bone. **Internal tuberosity.** Towards its middle is the *internal tuberosity* of the *body* of the humerus, which gives attachment to the common tendon of the teres internus and latissimus dorsi. On its lower third is the principal nutrient foramen of the bone.

Extremities. The *superior extremity*, the larger of the two, is divided into three parts:—a posterior, forming the head of the bone, and two antero-lateral, constituting its *tubercles*. **Head.** The head can scarcely be said to be detached from the shaft; it is rounded, representing the segment of a sphere, and covered with cartilage of incrustation to articulate with the glenoid cavity, which has not more than half its superficial dimensions. **External tubercle.** The *external* or *great tubercle* consists of three parts: (*a*) one in front, forming the outer edge of the bicipital groove, is a rugged projection to which is inserted the outer tendon of the antea spinatus; (*b*) another immediately behind, rounded and encrusted with cartilage to facilitate the passage of the tendon of the postea spinatus; (*c*) below and midway between the two is the third part, a rugged surface for the insertion of the tendon just named. **Internal tubercle.** The *internal* or *lesser tubercle* may also be divided into three surfaces—a superior, rough, and giving insertion to the inner tendon of the antea spinatus—an anterior, very prominent, forming the margin of the bicipital groove internally, and giving attachment to the pectoralis magnus—a posterior, also roughened, for the insertion of the subscapularis.

Bicipital groove.

These tubercles are separated from one another anteriorly by a deep groove divided in two by a median prominence. This is called the *bicipital groove* from its lodging the tendon of the caraco radialis or *biceps*. The upper margin of the groove is separated from the head by a deep fossa, in which are numerous vascular foramina, and which, in the fresh state, lodges a small quantity of fat.

Condyle. **Trochlea.** **Epitrochlea.** **Epicondyle.** **Coronoid fossa.** **Olecranian fossa.**

The *lower extremity* of the humerus is flattened from before backwards, and curved forwards, presenting its greatest diameter transversely. It has a broad articular surface, convex from before backwards, and divided into two parts by an antero-posterior groove. The internal part, much more bulky than that outside the groove, is called the *condyle*. The external is termed the *pulley* or *trochlea*, from a shallow groove which runs along it in an antero-posterior direction. The internal lip of this pulley is more prominent than the external. Corresponding to each of these articular surfaces are bulky eminences of insertion—the outer, called the *epitrochlea*, gives attachment to the extensor metacarpi magnus, extensor pedis, and in a deep fossa in the axis of the articular surface, to the external lateral ligament of the elbow-joint; also by its posterior part, to the flexor metacarpi externus. The inner eminence, designated the *epicondyle*, is larger, is more projecting in a backward direction, and gives attachment to the flexors metacarpi internus and medius, to the flexors pedis perforans and perforatus, and to the internal lateral ligament of the joint. Above and in front of the median groove which separates the trochlea from the condyle is a depression (coronoid fossa) for receiving the coronoid process of the radius during extreme flexion of the fore-arm. At the posterior extremity of the same groove, and between the epitrochlea and the epicondyle, is a large and deep fossa (olecranian) for receiving the olecranon during the extension of the fore-arm.

Structure.

The shaft of the humerus is hollowed out by a large medullary cavity, surrounding which is a layer of compact tissue, thickest internally. Cancellated tissue only exists in the extremities.

Development.

The *ossification* of this bone commences before that of the vertebræ. It has six centres of ossification. From one of these the entire body is formed. There is one centre each for the head and the external tubercle, which unite early to form the upper epiphysis of the bone; this is anchylosed to the shaft at a late period. The lower epiphysis is formed from three centres, one for the articular surface, another for the epicondyle, and a third for the epitrochlea.

Ruminants.

Differences.—In the *ox* the humerus is more bulky at its extremi-

Outer tubercle is hook-like.

ties; its head is elongated transversely and is pyriform. The external tubercle projects more superiorly, and is turned inwards over the bicipital groove, which is not divided by a median eminence. The internal and external tubercles of the body are only marked by slight asperities. In some cases an osseous plate extends from one side of the medullary canal to the other. All the domestic animals, other than the horse, have the nutrient foramen on the posterior surface of the bone.

Pig.

In the *pig* the configuration of the humerus resembles that of ruminants. The bone is relatively longer, and the head has a more backward direction.

Dog and cat.

Simple bicipital groove.

Hole in the coronoid fossa.

Cat has a hole in the epicondyle.

In the carnivora the humerus is proportionately longer than in any other domestic animal. The head is more detached from the bone, and has a backward direction. The external tubercle is largely developed, and the bicipital groove simple. The internal half of the lower extremity forms a condyle which projects inwards. The coronoid and olecranian fossæ are separated by an exceedingly thin bony plate, which is often perforated so that they communicate freely. The internal lip of the trochlea is even more prominent than the condyle. In the feline species an osseous arch is formed on the epicondyle for the passage of the median nerve.

FORE ARM (MIDDLE ELEMENT).

This element of the limb is formed by two bones, the *radius* and the *ulna*.

RADIUS.

Position.

Direction.

Form.

This bone is placed in front of the ulna, with which it is anchylosed in adult life. It is nearly vertical in direction, and extends from the humerus to the carpus. It is flattened from before backwards, bent upon itself in a similar direction, and for the purposes of description may be divided into a *body* and *two extremities*.

Surfaces.

The *body* presents an *anterior* and a *posterior* surface, separated by two lateral borders. The *anterior* surface is convex from side to side and perfectly smooth. Its inner half is subcutaneous, the outer covered by the extensor muscles. The *posterior surface* is flattened, and presents towards the external margin of its upper half a rugged triangular surface, corresponding to the anterior surface of the ulna, to which it becomes ossified. The base of this surface is superiorly, and here we find a transverse sulcus, which concurs in the formation

Radio-ulnar arch. of the *rădio-ulnar arch.* At the union of these parts internally is the principal nutrient foramen of the bone. The borders that separate the anterior from the posterior surfaces are rounded and smooth, passing gradually into the surfaces in front and behind.

Extremities, superior. The *superior extremity* has its greatest diameter in a transverse direction. Its articular surface corresponds to that on the lower end of the humerus. It presents, externally, two shallow antero-posterior grooves for the reception of the humeral trochlea; internally, a glenoid cavity into which the condyle is received; dividing these two is an antero-posterior eminence terminating in front in the coronoid process. **Coronoid process.** The *external tuberosity* is prominent, and gives attachment to the corresponding lateral ligament. The *internal*, corresponding to the bicipital tuberosity of man, gives attachment to the coraco-radialis. A roughened space below this last gives attachment to the internal lateral ligament and some fibres of the humeralis externus. On the posterior part of the head are two articular facets, transversely elongated, and corresponding to similar facets on the ulna; **Diarthrodial facets for the ulna.** below this a rugged surface descends to the radio-ulnar arch; the latter is united to the ulna by interosseous ligament.

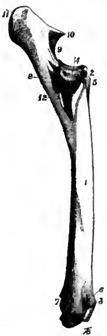

Fig. 111. Radius. 1, Body; 2, Head; 3, Lower end; 4, External tuberosity; 5, Internal tuberosity for the humeralis; 6, Groove for the tendon of the extensor pedis; 7, Styloid process of ulna fused with lower end of radius. Ulna. 8, Body, 9, Sigmoid notch; 10, Coronoid process; 11, Olecranon; 12, Radio-ulnar arch.

Lower extremity. The *inferior extremity* of the radius is flattened from before backwards. Its posterior surface is bounded by a prominent ridge, which gives attachment to the posterior common ligament of the carpus. **Grooved for tendons.** The anterior surface is convex, and marked by three grooves, two internal longitudinal and an external oblique. The internal groove gives passage to the tendon of the extensor pedis, the middle, the largest, to that of the extensor metacarpi magnus, while the external transmits the tendon of the extensor metacarpi obliquus. There is an internal and an external **Tuberosities.** tuberosity adapted for the insertion of the lateral ligaments of the carpus. The internal also presents a vertical furrow for the passage of the tendon of the extensor suffraginis. **Articular aspect.** The *articular surface* is irregularly quadrilateral, convex posteriorly, concave anteriorly, most prominent on its internal third, and with a hiatus posteriorly in its middle third. It articulates with the four bones composing the first range of the carpus.

Structure. The radius is formed of a very thick layer of compact tissue, with some spongy structure at the extremities. **Development.** It is developed from three points of ossification, one for the body, and one for each of the extremities.

ULNA (ὠλένη, ELBOW).

Position. In the adult horse this bone is anchylosed to the posterior surface of the radius. **Form.** It is an elongated and somewhat irregular bone, gradually decreasing in size from the upper to its lower extremity. It has a *median part* and *two extremities.*

Middle part. The *middle part* may be compared to a triangular pyramid with its base turned upwards, and having *three surfaces*, separated by *three borders.* The *anterior surface* presents, superiorly, two small diarthrodial facets, corresponding to those already noticed on the posterior aspect of the head of the radius. Below these is a small rugged space, which becomes united to the radius by interosseous ligament. Inferiorly to this is a smooth portion which contributes to form the *radio-ulnar arch.* **Radio-ulnar arch.** More inferiorly still is an elongated and triangular rugged surface, corresponding through an interosseous ligament to a similar surface on the posterior aspect of the radius. The external surface is slightly convex, and is covered by the flexor metacarpi externus. The internal surface, smooth and slightly concave, is related to the flexors of the foot.

Lower end. The *inferior extremity* ends in a sharp point toward the lower fourth of the radius. In some breeds of horses, and in the donkey and mule, it is frequently prolonged to the lower end of that bone. **Upper end. Olecranon.** The *superior extremity* is developed into a large process (the olecranon), flattened from side to side, and curved inwards. This terminates superiorly in a blunt tuberosity, to which is attached the extensor muscles of the fore-arm. The *external surface* is convex, the *internal* concave. The *anterior margin* is thin and sharp in its superior half; inferiorly it is concave from above downwards, and convex from side to side for articulation with the median groove on the lower articulation of the humerus. **Sigmoid cavity.** This part is called the *sigmoid cavity* (shaped like the letter S). Between these two parts is the projection of the olecranon, which is received into the olecranian fossa during extension of the fore-arm. The *posterior border*, concave and smooth, corresponds to the subcutaneous tissue.

Structure.

This bone has no medullary cavity. Its spongy structure is covered by a lamina of compact tissue, thick even in the olecranian portion.

Ossification.

It is developed from two centres of ossification, one for the shaft and one for the olecranon.

Ruminants.

Ulna extends to the knee.

Two radio-ulnar arches.

Vascular fissure.

Differences in the bones of the fore-arm.—In the *ox* the radius is shorter and more bent than in the horse. It does not articulate with the pisiform. The ulna is elongated to the level of the lower extremity of the radius, entering here into the formation of the surface which articulates with the first row of carpal bones. It forms, with the radius, two radio-ulnar arches, one superior, the other inferior. Between these arches the external aspect of the bone is traversed by a vascular fissure. The inferior extremity of the bone bears a groove which gives passage to the tendon of the lateral extensor of the phalanges.

Ossification.

The ulna is developed from three centres of ossification, one for the shaft and one for each extremity.

The two bones become ossified together above the superior radio-ulnar arch, as well as below it.

Small ruminants.

In the *sheep* and *goat* these bones have the same conformation, only they are relatively longer.

Pig.

In the *pig* the ulna is a large and important bone, and is possessed of a medullary cavity. It forms part of the carpal articular surface, and is seldom ossified to the radius with which it is, however, intimately connected. The olecranon is very prominent.

Dog and cat.

Olecranon long.

Lower end of the ulna has a styloid process.

In the *carnivora*, and especially in the *cat*, the two bones of the fore-arm are articulated together so as to be moveable, not only on the humerus and foot, but also on one another, in the acts of pronation and supination. The ulna has a long olecranon, a point of great importance in leaping. It presents, also, a great sigmoid cavity, for articulation with the humerus. Immediately below the greater is a small sigmoid cavity for the reception of a small and rounded articular facet on the radius. The coronoid process is well marked. The inferior extremity of the ulna is prolonged into a styloid process, to which the pisiform is attached; at the base of this process is a small circular facet for articulation with the radius. The shaft of the bone is triangular, and slightly twisted upon itself.

The radius is placed in front of the ulna, which it crosses obliquely

Lower end of the radius has a styloid process.

from without inwards. It enlarges at its inferior extremity, where it articulates with the scaphoid; it is likewise provided with a styloid process. The anterior surface of this extremity presents grooves for the extensor tendons. The head of the radius presents a slightly concave surface, corresponding to the condyle of the humerus; on its inner aspect is a semi-circular facet, articulating with the bent sigmoid cavity. On the inner side, and below the neck, which is embraced by the coronary ligament, is the bicipital tuberosity.*

Facet for the ulna.

THE ANTERIOR FOOT (DISTAL ELEMENT).

Component parts.

That part of the horse's limb, commonly called the foot, is in reality the extremity of the digit. In a more comprehensive sense, the foot comprises the *carpus* (the knee of our greater quadrupeds), the *metacarpus*, and the *three phalanges*. The anterior foot of the horse, thus viewed, corresponds to the hand of man.

CARPUS.—KNEE.

Position.

Structure.

The carpus (*καρπω*, I seize), placed between the fore-arm and the metacarpus, is made up of seven or eight small bones, disposed in two ranges; the upper range contains four bones, the lower three, and in some cases four.

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* In all mammals, the skeleton of the fore-arm consists of two bones, more or less distinct from each other, and varying in their relative size and in their connexions. Cuvier laid down as the result of his observation, and as a rule, that the development of the ulna was in direct relation to the division of the foot. Thus in man, monkeys, elephants, and carnivora, in which the hand or foot is divided into five digits, the ulna is fully developed, extends from the elbow to the wrist, and becomes the principal bone of the fore-arm. In ruminants, which have two fingers, the ulna, though extending from the elbow to the knee, is imperfectly developed in other respects; while in solipedes, which walk on the extremity of a single toe, it is more imperfect still.

Cuvier found, moreover, that the connexion between the radius and ulna becomes the more intimate the more exclusively the anterior extremities are used for standing or walking. Thus in animals, such as the horse, ruminants, and pig, in which the anterior limb is used only as a means of support, the two bones are not susceptible of moving on each other, and are often completely ossified together. In such animals as the carnivora and monkeys, on the other hand, in which the anterior limbs are used for digging, climbing, or as organs of prehension, the radius and ulna are united by their extremities only, and move freely upon each other, permitting the limb to be brought into the positions of pronation and supination.

Upper row. The superior or radial range is composed of the following bones, enumerating them from within outwards:—scaphoid, semilunar, cuneiform, and pisiform. This last bone is placed out of the range, projecting backwards on the outer side. Lower row. The inferior or metacarpal range, enumerating in the same direction, consists of the trapezoid, os magnum, and unciform. When the fourth bone, the trapezium, exists, it is embedded in the internal lateral ligaments.*

Form of the carpus. The two rows are so arranged as to present a slightly convex surface in front, and a concave surface behind. The latter is marked by several osseous projections, covered and rendered smooth by the posterior common ligament, which forms a canal for the passage of the flexor tendons.

BONES OF THE FIRST ROW.

Scaphoid. Forms. The *scaphoid* is the first and the largest of the row. Like all the other carpal bones, with the single exception of the pisiform, it is Aspects. irregularly cubical, presenting six surfaces, a superior, an inferior, an anterior, a posterior, and two lateral. It presents four articular facets, the superior of which corresponds to the radius, the inferior to the trapezoid and os magnum, and the two external lateral, which are smaller and separated by an inter-articular groove, to two similar facets on the semilunar bone. The anterior, internal, and posterior surfaces of this bone are rugged, and give attachment to ligamentous fibres. It articulates with four bones.

Semilunar. The *semilunar* bone is the second in size and position. It presents Aspects. six articular facets, one superior, concavo-convex, and corresponding to the radius: an inferior concavo-convex, corresponding to the os magnum and unciform. Of the four smaller lateral facets, two correspond to the scaphoid and two to the cuneiform. Its superior surface is triangular, with its apex posteriorly.

Cuneiform. The *cuneiform* bone, also called 'pyramidal,' is the smallest of the Surfaces. range. It has five articular facets by which it joins the surrounding bones. The superior one is concave, corresponding to the radius;

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* The names of these bones belong to the nomenclature of human anatomy, and have been given from their resemblance to certain objects, from their position, or some other circumstance—thus: scaphoid, boat-like; pisiform, pea-shaped, &c. Although the adoption of such names by the comparative anatomist is not justified by the shape of the bones, it has been found necessary to retain them for the corresponding bones, in order to preserve uniformity and avoid confusion.

the inferior, also concave, joins the unciform; two small facets on its inner side articulate with the semilunar bone. A concave facet on its posterior aspect corresponds to the pisiform. It consequently articulates with four bones.

Pisiform. Form.

The *pisiform* bone, placed on the outer and posterior aspect of the range, is flattened and oval in form. On the anterior part of its circumference are two articular facets; the superior one, concave, corresponds to the radius, the inferior, convex, joins the facet on the posterior aspect of the cuneiform. The external surface of the bone is convex and rough, with a groove anteriorly, giving passage to one of the tendons of the flexor metacarpi externus. The internal surface is concave, and forms part of the walls of the carpal arch. The superior part of its circumference gives attachment to the flexor metacarpi externus and medius; the inferior part to ligaments. It articulates with two bones.

BONES OF THE SECOND ROW.

Trapezium.

The *trapezium*, when present, which is generally the case in old horses, is a small rounded bone, placed at the postero-internal part of the range, and imbedded in the internal lateral ligament, immediately above the head of the small metacarpal bone. We have seen it provided with two articular facets, one for the metacarpal bones, the other for the trapezoid.—(Dr Monastier).

Trapezoid. Surfaces.

The *trapezoid* bone, the smallest of the whole carpus, the trapezium excepted, presents five articulating facets—one superior, corresponding to the scaphoid; one inferior, articulating with the small internal metacarpal bone. By the other three facets, which are on its lateral external surface, it joins with the os magnum. It is concealed under the lateral internal ligament, to which it gives attachment. It articulates with three bones.

Magnum. Aspects.

The *os magnum*, as its name indicates, is the largest bone of the carpus. It has also the greatest number of articular facets. One of these is superiorly and nearly flat, articulating with the scaphoid and semilunar; one, inferiorly, corresponds to the larger and internal small metacarpal bones. Three small facets on its internal surface correspond to the trapezoid, and two on its external unite with the unciform. It articulates with six bones.

Unciform. Surfaces.

The *unciform* bone occupies a median place as regards size, when compared with the two other bones of the lower row. It has four articular facets—one superiorly, corresponding to the semilunar and cuneiform; one inferior, having a median ridge, and articulating with the large and external small metacarpal bones. The two remaining facets are on its internal surface, and articulate with the os magnum. It articulates with five bones.

Structure of the carpal bones.

Each of the carpal bones is composed of close cancellous tissue, surrounded by a thick layer of compact bone. They have each a single centre of ossification.

Ossification.

Differences.—Not only the presence of the carpal bones, but their arrangement in two rows, holds good throughout the whole mammalian class. Their number varies, however, being increased by intercalation of additional bones, or diminished by the ossification of two or more into one.

Number varies in different animals.

Ruminants have six bones in the carpus.

In the *ox* there are six carpal bones, four in the first, and two in the second range. The pisiform, much smaller than in the horse, has no connection with the fore-arm, nor any groove on its external surface for the tendon of the flexor metacarpi externus. The scaphoid articulates with the radius, the semilunar and the trapezoid. The semilunar articulates with the scaphoid, the radius, the cuneiform, and the two bones of the second range. The cuneiform articulates with the external bone of the second range, with the semi-lunar, with the radius and ulna, and supports the pisiform. The bones of the second range articulate below with the large metacarpal. The external, the larger of the two, represents the os magnum and the cuneiform anchylosed together.

Magnum and unciform united.

Pig has eight bones.

The carpus of the *pig*, like that of man, contains eight small bones, four in each row. The cuneiform, by its superior surface, articulates most largely with the ulna; the pisiform articulates with the cuneiform only. The trapezium is rudimentary, ending in a blunt point. The trapezoid articulates with the two internal metacarpals, the magnum with the large internal metacarpal, and the unciform with the two external metacarpals. The bones of this last row diminish in size from without inward.

Carnivora.

Scaphoid and lunar anchylosed.

In the *dog* the carpus is composed of seven bones, three of which belong to the upper row. From the coalescence of the scaphoid and semilunar we have a single bone, the scapho-lunar, which articulates above with the radius, and below with the four bones of the second range. The cuneiform articulates with the ulna, the scaphoid, the unciform, the internal metacarpal, and the pisiform. The pisiform is prismatical, slightly enlarged at its extremities, and articulates with the ulna and cuneiform. The trapezium corresponds to the internal metacarpal (the homologue of the human thumb), the trapezoid to the metacarpal of the first toe, the os magnum to that of the second toe, and the unciform to that of the third toe, while the fourth toe is attached to the cuneiform and the unciform conjointly. The bones of the lower row increase in size from within outward.

Scaphoid and lunar are not anchylosed in the cat.

The carpus of the *cat* is in every way analogous to that of the dog, with this exception, that in the young animal the scaphoid and lunar bones are not confluent.

THE METACARPUS.

Position. **Three bones.**

This forms the second or middle portion of the foot, being situated between the carpus and phalanges. In solipeds it is composed of three bones, the principal of which is called the large metacarpal, while the two rudimentary bones, attached to the lateral parts of the former, are distinguished by their position into *internal* and *external* small *metacarpals*.

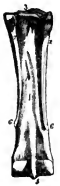

Fig. 112.

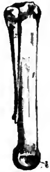

Fig. 113.

Fig. 112. Back view of the Large and Small Metacarpal Bones. Fig. 113. External view of Metacarpal Bones. 1 1, Large metacarpal bones; 2 2 2, Small metacarpal or splint bones; 3, Depression for the fetlock attachment of the lateral ligament of the joint; 5, Surface to articulate with the os suffraginis; 6 6, Diverging and tuberous inferior extremities of the small splint bones.

Cannon bone.

The *large metacarpal* or *cannon bone*, through which alone the weight of the body is transmitted to the phalanges, is a long cylindri-

Direction. cal bone, placed in a vertical position, and is divisible into a *body* and *extremities.*

Body. **Surfaces.** The *body,* which is slightly compressed from before backward, has its *anterior surface* convex and smooth. The *posterior surface* is flattened, and presents on each side an elongated rugged surface, extending from the superior extremity to the lower third of the bone, and giving attachment to the ligaments binding the large to the smaller bones. Between these two surfaces, on the upper third of the **Nutrient foramen.** bone, is the principal nutrient foramen.

Extremities. The *superior extremity* is elongated transversely. It presents, superiorly, the articular surface, which corresponds to the os magnum and unciform; on each side posteriorly are two small diarthrodial **Facets for the splints.** facets for articulation with the head of the corresponding small metacarpal, and in the median line some asperities for the insertion of the suspensory and metacarpal ligaments; on its antero-internal aspect is a rugged tubercle, giving insertion to the tendon of the extensor metacarpi magnus. The *inferior extremity,* also transversely elongated, presents a large articular surface, convex from before backward, and divided into two condyles by an antero-posterior articular ridge. The **Inner condyle is the larger.** internal of these condyles is the larger. On each side, in the axis of the condyle, is a fossa for the insertion of the corresponding lateral ligament.

Structure. Like all long bones this only contains spongy matter at its extremities. Its compact layer is very thick, and extremely close in texture, showing an almost ivory consistence when sawn through. It **Development.** is developed from two osseous centres, one for the shaft and superior extremity, the other for the lower epiphysis.

Splint bones. **Position.** **Form.** The *small metacarpal* or *splint bones* are placed at the postero-lateral parts of the cannon, to which they are intimately attached. They are pyramidal in form, generally more than two-thirds the length of the cannon, and are divisible into a *head* and *body.*

Head. The *head,* roughened and tuberculated for ligamentous insertion, presents on its anterior aspect two small facets, separated by a median groove, corresponding to similar facets on the large metacarpal. On its superior aspect is another facet which articulates with one or two of the lower range of carpal bones.

Body is trifacial. The *body* is trifacial, the three surfaces being separated by the same number of very distinct borders. The anterior surface is rugged, and articulates with the cannon bone. The internal and external are smooth throughout, the former bounding, laterally, the canal which lodges the suspensory ligament; the latter is the most frequent seat of those bony exostoses known as *splints*. The three surfaces converge inferiorly, ending in a knob, called the button, which is invariably detached from the principal metacarpal.

Seat of splint.

The internal small metacarpal is always the thicker, and often also the longer of the two; it is further distinguished by its superior articular surface being formed of two facets, which articulate respectively with the trapezoid and magnum.

Differences in the right and left splint bones.

These bones are chiefly composed of compact tissue, and contain no medullary canal. They grow from two centres of ossification; one for the head and body; the other, sometimes wanting, for the button.

Structure.

Development.

Differences.—The *metacarpus of ruminants* is composed of two bones, one large metacarpal, with the smaller articulated to its lateral external part. This last is much less developed than those of the horse, and has no connection with the second row of carpal bones. The large metacarpal is traversed in the middle of its anterior surface by a vascular groove, from which, in its lower third, a canal pierces the bone opening in the middle of its posterior surface into a similar longitudinal median furrow. These grooves are indications of the primitive binary division of the metacarpus. A deep notch in the inferior extremity of the bone affords attachment to ligaments, and divides the articular surface into two, each of which is again divided into two condyles by a median eminence. The medullary cavity is divided into two lateral parts by a vertical plate of bone, which becomes absorbed and perforated in the old animals. The small metacarpal, articulated by a diarthrodial facet with the large, is often wanting in the *smaller ruminants*.

Ox has only one small metacarpal.

Cannon is grooved on both anterior and posterior aspects.

Has a notch inferiorly.

Medullary canal divided by a plate.

Second bone is often absent in sheep.

In the *pig* the metacarpus consists of four bones, two large ones situated in the middle, and a small one placed at either side. The superior extremity of each bears facets by which it articulates with the carpus and with its fellows. The inferior extremity of each of the larger is constructed on the same principle as in the horse. That of each of the smaller bones is condyloid anteriorly, and pulley-shaped posteriorly, where it unites with a sessamoid bone.

Pig has four metacarpals.

The *carnivora* have five metacarpal bones of average length. The first, which corresponds to the thumb, is the shortest. The others increase in the following order as regards length and size:—the fifth, the second, the fourth, and the third. They are in close relation with each other at their upper extremity, where they articulate together by

In the dog and cat.

Form. diarthrodial facets, but they diverge slightly inferiorly. They are nearly cylindrical at their middle, but enlarge gradually towards the extremities. The inferior articulating surface is conformed like that of the cannon of the horse, and is extended upon the dorsal and ventral aspect of the extremity, so as to give great freedom of motion.

Ossification. Each is developed from two centres of ossification, one for the shaft and superior extremity, the other is an epiphysis for the lower extremity.

THE PHALANGES.

Three in number. The single digit of solipeds is carried by the large metacarpal bone. It consists of *three pieces* or *phalanges*, with *three* supplementary or sessamoid bones.

Names. Enumerated from above downward, they are designated first, second, and third. The first is also called the *pastern bone, os suffraginis,* and has superadded to it two *large* sessamoid bones. The second is named *os coronæ* or *coronet bone* (Bracy Clark). The third, termed *os pedis, unguial phalanx* (Rigot), or *coffin-bone*, has a super-added bone, the *lesser sessamoid* or *navicular*. These two bones join the coronet to form the articulation of the foot.

Pastern bone. Position and direction. The *Pastern Bone,* (os suffraginis), is placed between the lower extremity of the large metacarpal and the coronet, in a direction obliquely from above downward and forward. It is divided into body and extremities.

Body. The *body* is slighty flattened from before backward, and largest at its superior extremity. Its *anterior surface* is smooth and convex. The *posterior* is flattened, and presents a rugged triangular space, with its apex inferiorly, designed for ligamentous attachment. The two lateral margins merge gradually into the surfaces; they are roughened for the insertion of lateral ligaments.

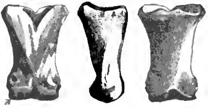

Fig 114. Fig 115. Fig 116.

Fig. 114. Side view of Os Suffraginis. Fig. 115. Front view of the same. Fig 116. Posterior view of the same.

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Extremities.

The *superior extremity* is transversely elongated, and much more bulky than the inferior. Its articular surface, which corresponds to the large metacarpal bone, is irregularly quadrilateral, and is formed by two lateral glenoid cavities, separated by an antero-posterior median groove. At each of the posterior angles is a tubercle roughened for the insertion of ligaments. Antero-externally are some asperities, giving insertion to the tendon of the extensor suffraginis. The *inferior extremity*, also transversely elongated, has an articular surface, corresponding to the os coronæ, and formed of two condyles, separated by a median depression. On each side is a small fossa, surmounted by a tubercle, both giving insertion to ligaments. Immediately above the condyles posteriorly is a depression into which the synovial membrane of the joint can recede under the anterior surface of the perforatus tendon.

Inner division of each articular end is largest.

In this, as in all the phalanges, the articular cavity, and the condyle on the external side, are invariably found to be smaller than those on the internal side of the bone.

Structure. Development.

This bone has a small medullary cavity surrounded by a thick layer of compact tissue. It is developed from two points of ossification, one of which is for the superior extremity.

Sesamoids. Position. Form.

The *large sessamoid bones* are placed at the posterior part of the upper extremity of the pastern, the articular surfaces of which they complete behind. Their *anterior surface*, the most important, is articular, and shaped as if moulded on the posterior part of the two metacarpal condyles and the antero-posterior eminence by which they are separated. The remaining part of each bone is embedded in a fibro-cartilaginous matrix by which they are connected to one another. Their superior, inferior, and lateral parts give insertion to powerful ligaments. Their posterior surfaces, with their connecting fibro-cartilage, form a groove supplied by a synovial membrane for the passage of the flexor tendons.

Form a groove for the flexors pedis.

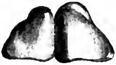


Fig. 117.
View of Anterior Surface of Sessamoid Bone.

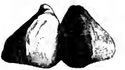
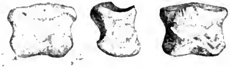


Fig. 118.
View of Posterior Surface of the same.

Os coronæ

The *coronet bone* (os coronæ) is a cuboid bone situated in a direction similar to that of the os suffraginis, and, like it, is somewhat bulkier at its upper than at its lower extremity. It presents four surfaces—a superior, an inferior, an anterior, and a posterior.



Os Coronæ.

Fig. 119. Back View. Fig. 120. Side View. Fig. 121. Front View.

Upper aspect. The *superior surface* is irregularly oval, and most prominent at its posterior border. It is formed of two glenoid cavities, separated by a slight antero-posterior elevation. The whole articular surface has a sharp and well-defined outline. The posterior border is tuberculated for ligamentous insertion; the anterior has also a small tubercle in the median line, giving insertion to part of the extensor tendon. **Lower aspect.** The *inferior surface*, convex from before backwards, and transversely elongated, is formed of two condyles separated by a shallow groove. The articular surface is prolonged upon the anterior, but more especially on the posterior aspect of the bone, corresponding in extent to that formed by the union of the os pedis and navicular bone. **Posterior surface.** The *posterior surface* is flattened, with its plane directed obliquely from behind forwards. At the upper margin is a transverse flattened eminence, which is covered by the glenoid fibro-cartilage of the joint, forming a pulley over which plays the tendon of the perforans. **Anterior surface.** The *anterior surface* is convex from side to side, and roughened for ligamentous attachments. Infero-laterally it presents two cavities with prominent roughened margins, giving insertion to the tendons of the perforatus.

Structure. The coronet bone is formed of a spongy nucleus surrounded by a very thick layer of compact texture, which imparts to it great strength. It is pierced by numerous vascular foramina. **Ossification.** It is developed from a single centre of ossification. In some subjects, a second exists for the posterior border of the upper surface. (Chauveau.)

Os pedis. **Form.** The *Os pedis* or *coffin-bone* is the basis segment of the bony column represented by the limb. It is a short bone, irregular posteriorly, but bearing a tolerable resemblance, by its anterior surface, to the section of a cylinder, and by its anterior circumference to the segment of a circle. It is divided into *three surfaces, three borders*, and *two extremities.*

Anterior surface,

The *anterior surface*, the more extensive of the three, is rough, convex from side to side, and directed from behind downwards and forwards.

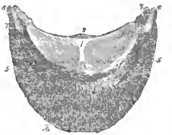


Fig. 122.

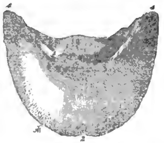


Fig. 123.

Fig. 122. Front View of Os Pedis. 1, Surface for articulation with os coronæ; 2, Surface for articulation with os naviculare; 3, Pyramidal process; 4, Eminentia patiloba; 5, Preplantar fissure; 6 6, Basilar processes; 7 7, Retrossal processes. Fig. 123. Inferior Aspect of Os Pedis. 1, Semilunar crest; 2, Notch on anterior part of the bone; 3 3, Plantar foramina; 4 4 Retrossal processes.

dense above, reticulated in middle, laminated below. Preplantar fissure. Patiloba, has numerous holes.

Superiorly, in the median line, the bone is compact, and pierced by five foramina; below this part it becomes less dense, and presents a reticulated appearance. Lower down it assumes a laminated structure, descending to the circumference, better marked toward the lateral than the anterior parts of the bone. On each side is the *preplantar fissure*, originating at the corresponding extremity between the basilar and retrossal processes, and running forward on the anterior aspect of the bone; it lodges the preplantar artery, the anterior division of the digital. Between this fissure and the margin of the bone is an elevation, the ***eminentia patiloba*** of Bracy Clark. The whole anterior surface of the bone is perforated by numerous foramina piercing its substance. One or two of the largest of these are found in the anterior extremity of the preplantar fissure; a number varying from eight to twelve, are arranged near the lower extremity of the surface, in a line parallel to its circumference.

Lower aspect. Semilunar crest. Plantar fissures and foramina.

The ***inferior surface***, concave both in its transverse and antero-posterior diameter, is divided into two portions by a parabolic ridge, called the ***semilunar crest***. The anterior portion, the largest, is more compact in the median line than toward the extremities, and presents numerous small foramina which give it a porous aspect. The posterior portion, more deeply excavated than the anterior, presents laterally two fissures running forward from the posterior aspect of the basilar processes to terminate in two large vascular foramina plantar foramina), which penetrate the interior of the bone. These are termed the plantar fissures, and lodge the corresponding division

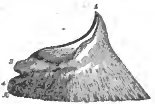


Fig. 124.

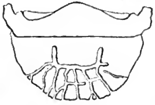


Fig. 125.

Fig. 124. Side view of Os Pedis. 1, Pyramidal process; 2, Preplantar fissure; 3, Basilar process; 4, Retrossal process. Fig. 125. Diagrammatic view of the Semicircular Canals.

of the digital artery. The *semilunar crest,* which separate these parts, runs backward to terminate in the retrossal process on either side, and gives insertion to the tendon of the flexor pedis. The *superior aspect* is an irregularly oval, articular surface, formed of two glenoid cavities, separated by an antero-posterior eminence. This surface looks upwards and backwards, and articulates with the lower extremity of the os coronæ.

Superior aspect has two cavities.

Borders.

The *superior border* of the bone separates the anterior from the articular surface. It is semicircular and undulating, presenting in its median part a process (*pyramidal* or *coronary*) upon which the tendon of the extensor pedis takes its insertion. At the base of this process, on either side, is a depression giving insertion to the antero-lateral ligament of the joint. The inferior border, sharp, notched, and semicircular, separates the inferior from the anterior surface. The posterior border, the shortest, separates the superior from the inferior surface, and connects the two basilar processes. It presents a triangular facet, continuous with the superior surface, and articulating with the navicular bone.

Pyramidal process.

Angles.

The *extremities* or *angles* are two eminences projecting backward, into which converge the three margins of the bone. Each is divided into two parts by the preplantar fissure, is covered with asperities, and supports the lateral cartilage. The superior of its two divisions is called the *basilar process,* the inferior, which is large, tuberculated, and spongy, is termed the *retrossal process.*

Basilar process.

Retrossal process.

By making a section of the bone through the lower third of its anterior surface, and on a line parallel to its inferior border, a large cylindrical and semicircular cavity is exposed. This is termed the

Semilunar sinus.

semilunar sinus; it is situated a little above and in front of the semilunar crest, on a plane parallel to the lower surface, and by its anterior convex border, to the inferior border of the bone. The semilunar sinus opens posteriorly through the plantar foramina into the plantar fissures. It communicates with the anterior surface of the bone chiefly by two sets of canals. One of these sets passes upward, and opens into the preplantar foramina in the anterior extremity of the preplantar fissure; the other consists of five or six canals originating from the convexity of the sinus, which take a downward direction, branch and anastomose freely with one another, and ultimately open near the lower margin of the anterior surface, through the ten or twelve foramina already mentioned.

Structure.

Development.

The bone consists chiefly of spongy tissue. The compact structure, which is most abundant at the coronary process, sends projections into the interior part of the bone to form the walls of the semilunar sinus, and of the numerous other vascular canals. It is developed from a single centre of ossification.

Lateral cartilages and plantar cushion.

The third phalanx is terminated posteriorly by a fibro-cartilaginous apparatus, consisting of the *lateral fibro-cartilages* and the *fatty frog* (plantar cushion, *coussinet plantaire* of the French writers), which are intimately connected with each other. These will be found described in another part of this work. It need only be mentioned here, that the lateral cartilages, which are continuous with the extremities of the bone, become gradually invaded by ossification, so that the backward projection of the angles always increases with age. The notch which separates the basilar and retrossal processes, is frequently converted into a foramen by this deposit of bone.

Navicular bone. Form.

The *navicular bone* is the sessamoid connected with the posterior part of the third phalanx. It is flattened from above downwards, elongated from side to side, broad in its median part, and pointed at either extremity.

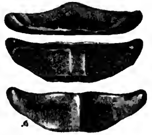


Fig. 126. Side View.

Fig. 127. Front View.

Fig. 128 Back View.

Navicular Bone.

Upper aspect. Its *superior surface*, which is articular, is formed of two depressions separated by an antero-posterior eminence, and forms the posterior part of the articular surface, which corresponds to the lower extremity of the coronet bone. Lower aspect. The *inferior surface* is also covered by cartilage, and separated into two lateral portions by a slight median elevation. This surface is provided with a synovial bursa, and forms a pulley for the tendon of the perforans. Anterior border. The *anterior margin* presents a transversely elongated facet for articulation with the coffin-bone, and below this, a groove for the insertion of the interosseous ligament. Posterior border. Its *posterior margin* and its *extremities* give attachment to the postero-lateral ligaments of the articulation of the foot.

Structure and ossification. This bone is almost entirely formed of compact tissue, and like the larger sessamoids, is developed from a single ossific centre.

Digital region of ruminants. *Differences in the digital region.*—The phalanges, constituting the two digits of *ruminants*, are constructed on the same principle as those of the horse, with some slight peculiarities indicative of their division. Each digit consists of three phalanges and three sessamoids. It may be mentioned, as a constant character in the phalanges, that the external border is convex, and the internal flat. The external portion of all their articular surfaces, whether glenoid cavity or condyle, is invariably the largest. No basilar nor retrossal process. The third phalanx has no basilar nor retrossal process, and no complimentary fibro-cartilage. A remnant of the plantar cushion sometimes exists. The bone is pierced by two great foramina—two at the base of the pyramidal process, and one at the origin of the preplantar fissure. Sessamoids. The two great sessamoids articulate with each other by small diarthrodial facets near their anterior aspect. The small sessamoid is not pointed at its extremities.

The pig has four digits. The *pig* has four complete digits, carried by the four metacarpal bones. The two lateral ones do not normally come into contact with the ground. The two median bear a close resemblance to those of ruminants.

Carnivora. The arrangement of the digits in *carnivora* closely resemble those of the hand of man in the position of pronation. There are four complete digits, each having three phalanges, and one, corresponding to the thumb, with two. The four fingers have two sessamoid bones each, that corresponding to the thumb only one. The form of the individual phalanges in each of the four digits is identical with those of the others. First row of phalanges. The body of the phalanges of the first row are semi-cylindrical, and slightly arched upward. The proximal end bears a

Sessamoids. Middle row of phalanges. Third row of phalanges.

glenoid cavity, enlarged posteriorly by the two sessamoids, and articulating with the lower extremity of the metacarpal; the distal end is pulley-shaped, joining the next phalanx. The sessamoid bones are trifacial, and somewhat like the divisions of an orange. The middle row consists of four bones (that of the first phalanx being absent), each of which bears on its distal end a comparatively large head, the articular surface of which is prolonged upon the ventral and dorsal aspects of the bone. The third row consists of five pieces, one for each of the digits. Each is composed of an anterior conical portion, flattened laterally, curved downward, and covered in the fresh state by the claw; it is surrounded at its base by a thin lamina, and between these parts is a circular groove lodging the matrix of the claw. Inferiorly is a small tubercle, representing the small sessamoid, forming a point on which the animal rests, and giving attachment to the flexor profundus digitorum. The base of the phalanx presents an arthrodial, concave surface, articulating with the bone of second row; above this, the bone is roughened for the insertion of the elastic ligaments which retract the claws.

Development.

Each bone of the first and second rows is developed from two centres of ossification, those of the third from one centre only.

HIND LIMBS.

THE HAUNCH.

The haunch bone forms the hæmal arch of the sacrum. Each side is primarily formed of three pieces. Their names; are called innominate or coxal bones. Form.

The bones composing the haunch contribute to the formation of the hæmal arch, attaching the posterior extremities, and hold a similar position in reference to these last as the bones of the shoulder do in relation to the fore-leg. Like as the typical shoulder is composed of three bones in each side—viz., the scapula, the coracoid, and the clavicle—so is the haunch formed of three on each side—the ilium (os ilii), the ischium (os ischii), and the pubis (os pubis). These three bones constitute individual parts of particular vertebræ, and are quite distinct in the young animal, but in the adult they have become confluent, and constitute a single large bone on either side, called the *innominate bone* (os innominata). This bone is constricted in its middle part, where it presents, externally, a deep articular cavity; it becomes enlarged and flattened anteriorly, where it is supported on the sacrum, while, posteriorly, it is expanded and turned inward to unite with its fellow in the median line, and to form the floor of the pelvis. For convenience of description, the three constituent parts will be considered separately.

Ilium: its form and position.

Ilium.—The ilium, the largest and the most anterior of the three, is flattened, triangular, slightly curved upon itself, and is directed from above, obliquely, downwards, backwards, and outwards. It has two surfaces, three borders, and three angles.

External surface. **Internal surface.**

The *external* or *dorsal* surface is concave from side to side, hence called the iliac fossa. It bears some asperities for muscular insertion. The *ventral surface* has, externally, a smooth portion, giving attachment to the iliacus, and bearing several transverse furrows for vessels; internally, an articular facet, transversely elongated, turned forwards, downwards, and slightly inwards, and surmounted by a rough irregular surface, giving insertion to the sacro-iliac ligaments.

Borders. Anterior. External. Internal.

The *anterior* or *lumbar border* is concave from side to side, and covered by rugosities, which give attachment to the ilio spinalis. The *external border*, also concave, is thick and rounded from above downwards, with several furrows for the ilio muscular veins, and towards its lower part a large nutrient foramen. The *internal* or *ischial border*, very concave posteriorly, is thin and sharp, giving attachment to the sacro-sciatic ligament, and contributing to the formation of the arch through which passes the gluteal arteries and nerves.

Angles. External. Internal. Posterior helps to form the cotyloid cavity. Supra-cotyloid crest. Ilio-pectineal crest.

The *external angle*, called also the angle of the haunch, is quadrangular, bearing four tuberosities, two superior, and two inferior, which give attachment to muscles. The *internal angle*, rugged and turned upward and backward, gives attachment to the superior sacro-iliac ligament. The *posterior angle* is thick and prismatical, entering into the formation of the cotyloid cavity. It presents, posteriorly, a large concave articular facet, forming the antero-external part of the cavity just mentioned; in front of this, two roughened depressions for the insertion of the two tendons of the rectus femoris; superiorly, is a sharp crest (supra-cotyloid), smooth internally, and rough externally, to give attachment to the gluteus internus; anteriorly, the *ilio-pectineal crest*, which, from a slightly marked ridge, rising on the lower surface of the ilium, becomes gradually more prominent, and ends in the anterior border of the pubis.

Pubis. Position, direction, and form.

Pubis.—This bone is placed at the infero-anterior part of the haunch; it is the smallest of the three, is elongated from within outwards, flattened from above downwards, and irregularly triangular. It may be divided into *two surfaces, three borders, and three angles.*

Surfaces.

The *external surface* is rugose for the insertion of the pectineus and external obturator muscles, and is traversed by a large groove, running obliquely outwards and backwards, to enter the cotyloid cavity by a Subpubian groove.

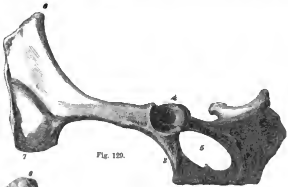


Fig. 129.

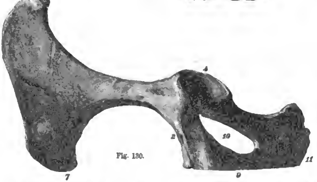


Fig. 130.

Fig. 129. Innominate Bone of Ox. 1, Ileum; 2, Pubis; 3, Ischium; 4, Acetabulum; 5, Obturator foramen; 6, Internal angle of the ileum; 7, External angle of ileum. Fig. 130. Innominate Bone of Horse. 1, Ileum; 2, Pubis; 3, Ischium; 4, Acetabulum; 5, Notch in the latter; 6, Supero-posterior spine of the ileum; 7, Antero-superior spinous process of the ileum; 8, Groove for the pubio-femoral ligament; 9, Margin of ischium and pubis, where the two innominate bones join to form the symphysis pubis; 10, Obturator foramen.

notch on its inner aspect. This lodges the pubio-femoral ligament and a large vein. The *internal surface* is smooth, forming part of the floor of the pelvis.

The *anterior* or *abdominal border* is turned upwards toward its Borders. inner extremity, and roughened for muscular attachment. The *internal* becomes anchylosed, in the adult animal, to the bone on the opposite side, forming the symphysis pubis. Symphysis pubis. The *posterior* is rounded and concave, forming the anterior boundary of the obturator foramen. Posterior border limits the obturator foramen.

At its inner part it is crossed obliquely by a fissure which lodges the obturator vessels.

Angles.
Outer helps to form the cotyloid cavity.

The *external* or *obturator angle* is the thickest. It bears a concave articular facet, bounded posteriorly by a roughened depression, which gives attachment to the round ligament, and allows the pubio-femoral ligament an exit from the joint. The *anterior angle* joins that of the bone on the opposite side. The posterior angle joins the antero-internal angle of the ischium, forming with it the inner border of the obturator foramen.

Ischium position and form.

Ischium.—Placed behind the ilium and pubis, this bone is flattened from above downwards, and forms the floor of the pelvis posteriorly. It is quadrilateral, and presents *two surfaces, four borders*, and *four angles.*

Surfaces.

The *superior* or *internal sruface* is smooth and concave. The *inferior* or *external* is roughened for muscular insertion, especially towards the symphysis.

Borders.
Symphysis ischii.
Posterior border gives attachment to the penis or clitoris.

The external border is thick, smooth, and concave, being in contact with the obturator internus, and pyriformis muscles, and sacro-sciatic nerve, during their exit from the pelvis. The *internal* becomes united to its fellow to form the ischiatic portion of the pelvic symphysis. The *anterior*, thick and concave, bounds the obturator foramen posteriorly. The *posterior border* is straight, thick, and rough, directed from without, inwards, downwards, and forwards. It is somewhat curved inferiorly, forming the ischiatic crest which attaches the penis in the male, and the clitoris in the female.

Angles.
Fissure for the sacro-sciatic nerve.
Ischiatic tuberosity.
Ischiatic spine.
Ischiatic arch.

The *antero-external* or *cotyloid* angle is the largest. It presents a concave articular facet, and more superiorly, the posterior extremity of the cotyloid crest, separated from the external border of the bone by a transverse fissure. The *antero-internal* angle joins that of the opposite bone. The *postero-external angle* bears two large tuberosities, the superior prismatic, and turned upwards, is called the *ischiatic tuberosity;* the inferior, turned downwards and outwards, is called the *ischiatic spine.* The *postero-internal angle* forms with that of the other ischiatic bone, the apex of a triangular notch, called the *ischiatic arch.*

The innominate bone as a whole.
Acetabulum.
Notch for the pubio-

The innominate bone, taken as a whole, presents a median constricted part, and two expanded extremities. On the external aspect of the median part is a hemispherical cavity (cotyloid cavity or acetabulum), bounded by a sharp and prominent margin on all, except its inner side, where it has a deep notch for the passage of the pubio-femoral ligament. This cavity is formed by the union of the three bones already described, the largest part being formed by the ilium, and the smallest by the pubis. The anterior extremity, flattened from without inwards, is supported by its internal angle on the sacrum. The posterior extremity, flattened from above downwards, forms the floor of the pelvis, and is perforated by the obturator foramen, which is closed in the fresh state by muscles.

femoral ligament.

Obturator foramen.

It articulates with three bones, the sacrum, the femur, and the opposite innominate bone. When the two bones are united, as they always are in the old animal, they bear some resemblance to the letter U, with its opening in front.

Articulations.

This, like all large bones, contains spongy structure internally, covered by a thin layer of compact tissue. This last is largely increased in that part of the bone surrounding the acetabulum. Besides a centre of ossification for each of the three great divisions, there are two supplementary ones, one for the external angle and anterior border of the ilium, the other for the ischiatic tuberosity, spine, and crest.

Structure.

Development from five centres.

Differences.—In the *ox*, the innominate bones have a less vertical direction, and the space between them does not widen anteriorly. The median part of each bone is less constricted, the cotyloid cavity is shallower, and its margin is formed by three eminences, indicating the parts formed by the individual bones. The *cotyloid crest* is well marked and sharp, with slight ridges on its outer aspect. The ilium is less expanded, and its outer angle bears only three tuberosities. The posterior part (ischium and pubis) is very concave on its superior aspect. The inferior surface of the pelvis shows no furrow, as this animal has no pubio-femoral ligament. In the middle of the ischio-pubic symphysis, inferiorly, is a great protuberance, developed from a separate centre of ossification. The ischiatic tuberosity, spine, and crest, represent three large conical processes, united by their bases.

Ruminants

Acetabulum has three eminences.

External angle of the ilium has only three tubercles.

Floor of the pelvis is very concave.

No subpubian furrow.

Tubercle on ischio-pubic symphysis.

In the *smaller ruminants* the iliac fossa is separated into two parts by a well-marked longitudinal crest.

Sheep and goat.

In the *pig*, these bones resemble those of the sheep, with the following exceptions:—The anterior border of the ilium is convex; there is no tuberosity on the ischio-pubic symphysis, and the ischiatic tuberosity, spine, and crest, form a single trifid tuberosity.

Pig.

In the *carnivora*, the space between these bones, and consequently the capacity of the pelvis, are greater behind than in front. The cotyloid cavity has a very prominent margin, with a slight notch internally. The supra-cotyloid crest is imperfectly developed. The

Dog and cat.

Space between the bones least in front.

position of the ilium is nearly vertical. The iliac fossa is formed by an excavation on the external surface of the bone, and not by twisting of the latter. There is no groove for the pubio-femoral ligament. The postero-external angle of the ischium bears a single tubercle, and the ischiatic notch is formed by the inner half only of the posterior border. In the *cat* the iliac fossa is almost entirely wanting.

Single tubercle on the posterior part of the ischium. No iliac fossa in the cat.

THE PELVIS.

Bones forming the pelvis.

Use.

The pelvis, or basin-shaped cavity, formed by the union of the sacrum, the root of the coccyx, and the innominate bones, deserves a separate notice. It is, properly speaking, a dependance of the abdominal cavity, with which it becomes continuous anteriorly, and it contains a number of very important organs connected with the digestive, urinary, and reproductive systems, its bony frame-work, meanwhile, acting as a medium through which the impulses of the posterior extremities are conveyed to the trunk.

Form.

The pelvis has the form of a truncated cone, slightly compressed laterally, and with its base turned forwards, its apex backwards. Its external and internal surfaces, and its anterior and posterior circumferences, call for short comment.

Surfaces. Supero-external aspect.

Lateral external aspect.

The *external* surface has four aspects:—the *inferior,* formed by the pubis and ischium, have been already noticed; the *superior,* formed by the sacrum, is the narrowest of the four, has a direction from above, obliquely, downwards, and backwards, a series of five spinous processes in the median line, and on each side a groove, containing five supra-sacral foramina;—each *lateral aspect,* directed from above, downwards, and outwards, is formed anteriorly by the iliac fossa, and posteriorly by the sacro-sciatic ligament, which occupies the great hiatus left in the skeleton between the sacrum and the iliac and ischiatic bones. This ligament is pierced by two large apertures, one in front, and one behind the cotyloid crest, for the passage of blood-vessels, nerves, and, in the case of the posterior one, of muscles.

Inner surface.

The *internal surface* is less extensive, and more regular than the external. *Inferiorly,* it is formed by the ischium and pubis; in the median line it presents the symphysis of these bones, and, laterally, the internal openings of the obturator foramina. It is partly covered by the obturator internus, and partly supports the bladder. *Superiorly,* it is formed by the inferior surface of the sacrum, and shows laterally, the inferior sacral foramina; this aspect is in contact with the rectum, the inferior sacral blood-vessels, and the sympathetic nerves. Each *lateral aspect* is in great part formed by the sacro-sciatic ligament; its surface is smooth, and on this ramifies the lumbo-sacral nervous plexus, and the gluteal, obturator, and sacro-sciatic nerves, with their accompanying blood-vessels.

Anterior circumference.

The *anterior circumference*, oval in a vertical direction, is formed superiorly by the sacrum, inferiorly by the anterior border of the pubis, and, laterally, by the venter of the ilium. It presents superiorly, in the median line, the articulation for uniting with the body of the last lumbar vertebra; inferiorly, in the same line, the prominence at the anterior extremity of the pubic symphysis; laterally, proceeding from above downward, on either side, the surface for articulation with the transverse processes of the last lumbar vertebra, a few asperities for the insertion of the psoas parvus, and the ilio pectineal ridge.

Posterior circumference.

The posterior circumference is formed above by the root of the coccyx, below, by the ischial tuberosities and crests, and, laterally, by the sacro-sciatic ligaments. This opening contains the inferior sacro-coccygeal muscles, the suspensory ligaments of the anus and penis, the rectum, the urethra, the prostates, the roots of the penis, the ischio-coccygeal, and ischio-anal muscles, and the vessels and nerves of the bulb, and of the inferior part of the tail; in the female, the dependencies of the generative organs passing through this opening are the vagina, the vulva, and the clitoris.

THE THIGH (PROXIMAL ELEMENT).

This part has only one bone, the *femur*, for its basis.

Femur: its position.

Femur.—This is a long bone, placed in an oblique direction from above downwards and forwards, articulating above with the acetabulum—below, with the tibia, For convenience of description, it may be divided into a *body* and *two extremities.*

Body.

The *body* is irregularly cylindrical, and has two surfaces, an anterior and a posterior. The *anterior*, the most extensive, is regularly rounded, and nearly smooth, having, however, some slight asperities superiorly and inferiorly. The *posterior* larger is above than below, nearly flat, and presents, (*a*) towards the external part of its superior third, a circular, slightly elevated, ridge; (*b*), on the inner side of this a slight crest, running from the internal trochanter downwards and outwards; (*c*), in the middle third a roughened quadrilateral surface, giving attachment to the adductor magnus; (*d*), and below this a large transverse groove for the popliteal vessels.

Trochanter minor externus.

Supra-condyloid fossa.

Trochanter minor internus.

Nutrient foramen.

On the *external border*:—toward the superior third is a great rugged projection, the *trochanter minor externus;* in the lower third a deep and roughened fossa, *supra condyloid*, giving attachment to the gastrocnemius externus. On the *internal border* we find, in the superior third, the *trochanter minor internus*, a thick process, roughened in front, and continued to the head of the bone by two lines, one nearly vertical, the other running upwards and backwards in the same direction as the bone; the *trochanter minor internus* is continued inferiorly by a crest which gives attachment to the pectineus, and is confounded posteriorly with the surface of insertion for the adductor magnus; in front of this line is the nutrient foramen

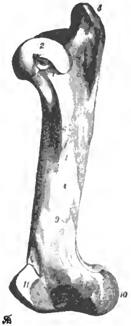


Fig. 131.

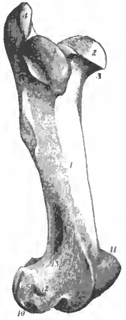


Fig. 132.

Fig. 131. View of External Surface of Femur. Fig. 132. View of Internal Surface of same. 1, Shaft; 2, Head; 3, Cervix or neck. 4 4 4, Trochanter major; 5, Trochanter minor externus; 6, Trochonter minor internus; 7, Notch on head of femur; 8, Trochanterian fossa; 9, Asperity for the attachment of muscle; 10, Condyles; 11, Articular surface for the patella; 12, Point of attachment for the external lateral ligament of the stifle joint, 13, Supra-condyloid fossa; 14, Internal lateral ligament of the stifle joint.

Supra-condyloid crest.

of the bone; and in the lower third is a rugged eminence, the *supra-condyloid crest.*

Superior extremity.
The head.
Neck.
A cavity on the inner aspect of the head.
Trochanterian fossa.

The *superior extremity* is flattened from before backwards, and presents two large eminences, the head and the trochanter major. The *head,* which is placed internally, is a large globular mass, covered with cartilage of incrustation, and received into the acetabulum, to which it corresponds in size; it is separated from the rest of the bone by a short constricted *neck,* and on its inner aspect is a fossa for the insertion of the round and pubio-femoral ligaments. The trochanter is divided into an anterior and a posterior part by a narrow notch; the posterior part, the most prominent, projects considerably above the level of the head; it is roughened and turned inwards superiorly, where it gives attachment to the gluteus medius. The anterior, larger, but less projecting, is convex superiorly, where it is covered by cartilage for the gliding of the gluteus medius tendon; below this convexity is a curved crest, to which the tendon just mentioned becomes attached. Posteriorly is a deep and roughened depression, the *trochanterian fossa,* circumscribed externally by a crest descending from the larger eminence of the trochanter; this fossa gives insertion to the gemini, the pyriformis, and the obturator muscles.

Lower extremity.
Condyles.
Inter-condyloid notch.
Trochlea.

The *inferior extremity* is flattened from side to side, and presents *two condyles* posteriorly, with a *trochlea* anteriorly. The *condyles* are arranged, one internally and the other externally, to correspond to the two articulating surfaces on the head of the tibia, and are divided by a deep notch for the reception of the tibial spine, and the inter-osseous ligaments of the femoro-tibial articulation. The *internal condyle* presents on its inter-condyloid aspect a rugose depression for the ligament of the fibro-cartilaginous disc, interposed between the external condyle and the head of the tibia: on its internal aspect is a considerable and roughened tubercle for ligamentous insertion. The *external condyle* bears on its outer aspect two small fossæ, the superior for ligamentous, and the inferior for muscular insertion. The *trochlea* is a large pulley-shaped surface, placed above and in front of the condyles, and continuous with the inter-condyloid notch. Of the two eminences which bound it laterally, the internal is at once the thickest and the most prominent. The external eminence is separated from the corresponding condyle by a roughened fossa, which gives insertion to the tendon common to the flexor metatarsi and the extensor pedis.

Structure.

The femur has two layers of compact tissue, one around the medullary cavity, the other covering the entire bone externally; between these is a layer of spongy tissue, which is especially abundant in the two extremities.

Ossification.

It is developed from four centres of ossification, one for the body, one for the lower extremity, one for the head, and one for the great trochanter.

Ruminants.

The ox has no small outer trochanter.

Differences.—In the femur of the *ox* the extremities are relatively larger, and the body smaller and more cylindrical than in the horse. There is no external small trochanter. The internal trochanter is rounded, and encroaches on the posterior aspect of the bone. The supra-condyloid fossa is shallow, and the supra-condyloid crest is little marked. The nutrient foramen is on the antero-external aspect of the upper third of the bone. The head is more detached from the body, and its roughened fossa is near the centre of the articular surface. The trochanter major is very large and projecting, without any notch, as in the horse. The trochanterian fossa, very deep and extensive, is bounded posteriorly by a ridge running diagonally from the great trochanter to the small internal trochanter. The trochlea is more projecting and narrower, the internal eminence being very much larger, and extending higher on the bone than the external. In the *smaller ruminants* the trochanter major is no higher than the articular head; the supra-condyloid fossa is scarcely marked; and the trochlea has its lateral eminences of equal height. In other respects the bone agrees with that of the ox.

Deep trochanterian fossa.

Trochlea narrow and projecting.

Sheep and goat.

Like in the ox.

Pig.

In the *pig*, the femur closely resembles that of the sheep. The head is, however, separated from the bone by a much more constricted neck, and is placed within and in front of the trochanter, so that the axis of the superior extremity crosses that of the lower obliquely, and not at right angles.

Dog and cat.

Long and curved.

Neck long.

The femur of *carnivora* bears a strong resemblance to that of man. It is remarkable for its great length, its want of thickness, its curvature forward, especially in the lower half, and the roughened line or linea aspera on its posterior surface for muscular insertion. The neck is long and much constricted, the trochanter major lower even than the head, the small external trochanter entirely wanting, the internal trochanter conical, and the trochanterian fossa very deep, and bounded posteriorly by an oblique ridge, running diagonally between the two trochanters like in ruminants. The supra-condyloid fossa is scarcely discernible, and is surmounted by a small tubercle.

THE LIMB (MIDDLE ELEMENT).

This is composed of three bones, the *tibia*, the *fibula*, and the *patella*. Has three bones.

Tibia: its form and position.

Tibia.—The *tibia* is a long prismatical bone, extending, in a direction obliquely downward and backward, from the femur to the tarsus. For facility of description it may be divided into a *shaft* and *two extremities.*

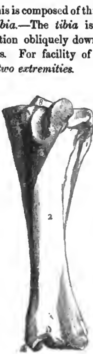


Fig. 133.

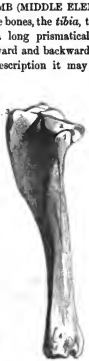


Fig. 134.

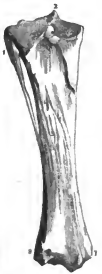


Fig. 135.

Fig. 133. Anterior view of the Tibia. 1, Fibula; 2, Shaft of the tibia; 3, Crest of the tibia; 4, Groove for the median ligament of the patella; 5, Anterior tuberosity of the head; 6, External tuberosity of the head; 7, Internal tuberosity of the head; 8, Tibial spine; 9, Internal malleolus. Fig. 134. External view of the Tibia. 1, Fibula; 2, External tuberosity of the head; 3, Tibial crest; 4, External malleolus. Fig. 135. Posterior view of the Tibia. 1, Fibula; 2, Labial spine; 3, Internal articular surface of the head; 4, External articular surface of the head; 5, Rugose posterior aspect of the body; 6, Nutrient foramen; 7, Internal malleolus; 8, External malleolus.

The shaft is prismatical.

The *shaft* has *three surfaces* and *three borders*. The *surfaces* all diminish in width from above downwards. The *external*, which is nearly smooth, is concave in its superior third, convex below, and turns round the bone so as to gain its anterior aspect inferiorly. The *internal* is convex throughout, and exhibits superiorly some asperities for the insertion of the adductor, and semitendinosus muscles. The *posterior surface*, nearly flat, is divided into two unequal triangular spaces, by a ridge running obliquely from without downwards and inwards; of these the superior, the least, is rugose, and gives attach-

Nutrient foramen.
Tibial crest.
Tibial arch.

ment to the popliteus; the inferior is grooved longitudinally at its superior part for the origin of the flexor perforans. At the point of union of these two parts, superiorly, is the nutrient foramen of the bone. The anterior border is rounded in its inferior two-thirds, but its upper third is sharp, prominent, and curved outward, so as to add to the concavity of the external aspect of the bone; this ridge is named the *tibial crest.* The *internal border* is thick and straight, with some tubercles superiorly for the insertion of the popliteus. The *external* is rounded and thick inferiorly, and concave superiorly, where it forms with the *fibula*, the *tibial arch.*

Upper extremity.
Anterior tubercle.
External tuberosity.
Internal tuberosity.
Articular surface.
Tibial spine.

The *superior extremity*, the larger, is formed of three tuberosities, *an anterior* and *two lateral.* The *anterior*, forming the superior extremity of the tibial crest, is a roughened projection, separated from the external by a deep notch for the passage of a tendon. It is the smaller of the three, and gives insertion to the three ligaments of the patella, the median filling up a groove on its summit. The *external tuberosity* is more detached than either of the other two, occupies the median position in point of size, and has on its outer aspect an articular facet for the head of the fibula. The *internal*, the largest and the least detached of the three, bears externally some asperities, and postero-internally a small tubercle, which gives insertion to the posterior band of the femoro-tibial interosseous ligament. The *articular* surface of this extremity consists of two facets, one for the internal, and one for the external tuberosity. These are separated by a central conical eminence (*tibial spine*), the lateral parts of which are smooth and covered by cartilage of incrustation, the summit bears a roughened furrow for the interosseous ligaments, and those of the fibro-cartilaginous discs. The two facets, slightly convex from before backwards, and concave from side to side, articulate with the condyles of the femur through the medium of two fibro-cartilages already mentioned.

Lower extremity.
Two anterior-posterior fossæ.
External malleolus.
Internal malleolus.

The *inferior extremity* consists of two deep articular cavities separated by a median eminence, and two lateral tuberosities. The *articular cavities* are deep, compressed laterally, and directed from within forward and outwards, like the pulley on the *astragalus.* The *external tuberosity*, or malleolus externus, is rough and prominent, with a vertical groove on its central part. The *internal tuberosity*, or malleolus internus, more prominent and rough, is bounded posteriorly by a groove running obliquely downwards and forwards.

Structure.
Ossification.

The structure of the tibia corresponds to that of all long bones; the compact tissue predominates in the lower extremity. It has four centres of ossification, one for the body, two for the superior extremity, one of these being for the anterior tuberosity; and, lastly, one for the lower extremity. A fifth centre sometimes exists for the external tuberosity of this extremity.

Fibula. Position. Form.

THE FIBULA is a rudimentary bone placed at the postero-external part of the tibia, and extending from its upper extremity to the middle of its lower third. It is a long styloid bone, and may be divided into a *body* and *two extremities.*

Body. Head. Lower end. Exceptions.

The *median part* or *body* represents a narrow cylinder, which concurs in the formation of the tibial arch. The *superior extremity* or *head* is much enlarged, and flattened from side to side; it presents, internally, a roughened facet, by which it joins the tibia, and, externally, numerous asperities for ligamentous attachment. The *lower extremity* ends in a blunt apex, bound to the tibia by a ligamentous prolongation. In some rare instances it is prolonged to the lower end of the tibia; considering this peculiarity, the position of the lower end of the fibula in the carnivora, and the fact that the external malleolus has sometimes a separate centre of development, the inference is plausible that the process just named represents the lower end of this bone.

Structure. Development.

Compact tissue predominates in the structure of the fibula, which is developed from a single centre of ossification.

Patella. Position. Surfaces.

THE PATELLA.—This is a short irregular bone placed in front of the femoral trochlea, and attached inferiorly to the anterior tuberosity of the tibia by three strong ligaments. It has *three surfaces,* an *anterior*, a *posterior*, and a *superior.*

Articular and inferior.

The *anterior* or *subcutaneous surface* is convex, quadrilateral, and roughened for tendonons and aponuerotic insertion. The *posterior* or *articular aspect* is composed of a median elevation and two lateral concavities, by which it becomes somewhat imperfectly adapted to the trochlea of the femur. The internal cavity is at once deeper and broader than the external, a circumstance which establishes a ready means of distinguishing the patella of the right from that of the left leg. The *superior surface* is the smallest, looks obliquely upward and backward, and is roughened for the insertion of the two vasti and rectus femoris muscles.

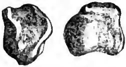


Fig. 136. Patellæ.

Structure. Development.

This bone abounds in cancellated tissue, and is developed from a single centre of ossification.

Ox.
Tibia bent.

Differences in the bones of the leg.—In *ruminants* the tibia is remarkable for being more twisted upon itself than in the horse, also for its being bent with an anterior concavity. It has no facet on the external, and no groove on the anterior tuberosity. The lower articular surface is most prominent internally ,and its articulating cavities are arranged in an antero-posterior, and not in an oblique direction, as in the horse. The external malleolus is detached, and forms a separate bone, representing the lower end of the fibula, and articulating above with the tibia, below with the astragalus and os calcis. The fibula is farther represented by a fibrous cord, extending from the upper to the lower extremity of the bone, and not unfrequently ossified in part or in whole. The patella is relatively smaller than in solipeds.

A small bone at the lower end is a part of the fibula.

Pig.
Tibia very prismatical.
Fibula flat and long.

In the *pig* the tibia closely resembles that of the smaller ruminants. It is, however, less twisted, less bent, and more prismatical. The tibial crest is very prominent. The *fibula* flattened from side to side, extends throughont the whole length of the tibia, to which it is united inferiorly by a diarthrodial facet, superiorly by a roughened facet, with interosseous ligaments; its shaft is separated by a narrow interval. It has three centres of ossification, one for the body and one for each extremity. The part developed from the lower centre corresponds in form, position, and articulations with the small separate bone in the ox.

Ossification of the fibula.

Carnivora.
Tibia.

The tibia of the *dog* and *cat* is long and thin, with a superior and an inferior curve in opposite directions. The tibial crest is very sharp and salient. The tibial spine little marked. On the postero-external aspect of each extremity is a diarthrodial facet, by which it joins the fibula.

The fibula.

The *fibula*, a long slender bone, flattened and twisted on itself in its median part, has on each extremity a diarthrodial facet, by which it joins those on the tibia, and on its lower half a rough internal surface for interosseous ligament, which binds it closely to the tibia. Its lower extremity articulates with the astragalus. Like in the pig, this bone is developed from three ossific centres.

THE POSTERIOR FOOT (DISTAL ELEMENT).

The posterior foot may be looked upon as comprising the *tarsus*, the *metatarsus*, and the *phalanges*, in the same way as the anterior foot is composed of the corresponding parts of the fore extremity.

THE TARSUS OR HOCK.

Its composition. This is formed by an aggregation of short, irregular, compact bones, placed between the lower end of the tibia and the upper end of the metatarsus, and arranged like those of the carpus in two rows, a superior and an inferior.

Individual bones. The *upper row* is composed of two bones only, the *astragalus* and *os calcis*, which are, however, the largest of the hock. The *lower* has posteriorly the *cuboid* only, but is divided anteriorly into two secondary rows—the superior of which is formed by the *scaphoid*, and the inferior by the *cuneiform magnum* and *parvum*.

The astragalus. Position. The *astragalus* is an irregularly cubical bone, placed in front of the os calcis, and between the tibia and scaphoid. It has *five surfaces*, a *supero-anterior*, an *inferior*, a *posterior*, and *two lateral*. Surfaces. Trochlea. The *supero-anterior surface*, moulded accurately on the inferior articulating surface of the tibia, is a trochlea, directed from above, forward, outwards, and downwards. At the bottom of the groove we frequently find a minute fissure for holding synovia. At the superior and inferior extremities of the pulley-like surface, are some asperities for ligaments, The *inferior surface*, slightly convex from before, backwards, presents two diarthrodial facets, the smaller one, the external, being separated from the inner by a roughened fissure for ligamentous insertion. It articulates with the scaphoid and cuboid. The *posterior surface* bears three or four diarthrodial facets, corresponding to similar surfaces on the os calcis, and separated from each other by deep and rugged depressions. The *external surface* is rough, with a circular fossa for the insertion of ligaments. The *internal* is also rugged, and bears a small tubercle of insertion inferiorly.

Os calcis. Position. The *os calcis* articulates with the astragalus posteriorly, and is placed in a direction from above, downwards, and forward. It is a short bone, and presents *two surfaces, two borders*, and *two extremities*.

Surfaces. Tarsal arch. The *external surface* is nearly smooth and flat. The *internal* has a large and smooth groove running downwards and backwards, which assists in forming the tarsal arch for the passage of the tendon of the perforans.

Borders. The *anterior border* is smooth, rounded, and slightly concave. The *posterior* much longer than the anterior, is straight, thick, and rough. Extremities. The *superior extremity*, considerably larger than the body, forms the point of the hock. It is divisible into three parts:—the posterior is concave from side to side, and, being covered in the fresh state by cartilage of incrustation, affords a surface of gliding for the tendon of the perforatus; the *median* is roughened, and gives attachment to the tendon of the gastrocnemii; the anterior, separated from that just mentioned by a slight notch, is convex, smooth, and covered by a cartilage of incrustation, over which plays the above-mentioned tendon during extreme flexion of the metatarsus. The *inferior extremity* is greatly expanded, chiefly in consequence of a large tuberosity on its internal part, which forms the floor of the tarsal arch. It presents anteriorly three or four diarthrodial facets for articulation with those on the posterior aspect of the astragalus, and separated by similar excavations. Inferiorly it bears two facets, for articulation with the cuboid, one of which is continuous with one on the anterior aspect.

Development. The *os calcis* has two centres of ossification, one of which is for the superior extremity.

Cuboid. **Situation.** The *cuboid bone*, situated outside the scaphoid and large cuneiform, between the os calcis above, and the large and external small metatarsal bone below, is not a cube, as its name would imply, but is elongated from before, backwards, so as to form a parallelopiped.

Surfaces. Its *superior surface* bears two facets for articulation with the os calcis, divided by a fissure for ligamentous insertion. The *inferior* has likewise two articular facets, by which it joins the large metatarsal and external splint bones. The *internal* has three facets, adapted to similar facets on the scaphoid and cuneiform magnum, and divided by a deep groove, which contributes to the formation of a vascular canal. The *anterior, posterior,* and *external surfaces* are rough, and bear two small tubercles.

Scaphoid. The *scaphoid*, placed on the inner side of the cuboid, between the astragalus and the two cuneiforms, is a flat bone, with *two surfaces*

Surfaces. and a *circumference*. The *superior surface*, concave from before, backward, has a large diarthrodial facet, articulating with the inferior surface of the astragalus, and divided posteriorly by a roughened groove running forward to the centre of the articular surface. The *inferior surface*, convex from before, backwards, has two facets, which unite with the two cuneiform bones, and are divided by a roughened

Circumference. depression for ligamentous insertion. The *circumference* is furnished with asperities, and presents externally two facets for articulation with the cuboid.

Cuneiform magnum. Form. Surfaces. Circumference.

The *cuneiform magnum* is situated in the inferior part of the hock, in front of the cuboid and cuneiform parvum, and between the scaphoid and large metatarsal bone. It is flattened from above downwards, triangular, with its apex posteriorly, and has *two surfaces* and a *circumference*. Its *superior surface*, slightly concave, and separated by a deep furrow into two diarthrodial facets, articulates with the scaphoid. Its *inferior*, also, bearing two facets, articulates with the cannon. Its circumference, bearing numerous asperities for ligamentous attachment, has three articular facets, two external, uniting with the cuboid, and an internal, joining a similar facet on the small cuneiform.

Cuneiform parvum. Position. Articulating surfaces. Structure.

The *cuneiform parvum*, the smallest bone of the tarsus, is placed in the postero-internal and inferior part of the joint, behind the cuneiform magnum, and between the scaphoid and the large and internal small metatarsal bones. It is elongated from without inward, flattened from before backwards, and presents four diarthrodial facets: —one superior, articulating with the scaphoid; one internal, articulating with the large cuneiform; and two inferior, responding to similar facets on the heads of the large metatarsal and internal splint bones. This bone is sometimes divided into two, so that there may be three cuneiforms like in the human subject.

Development.

The bones of the hock contain much compact tissue, and, with the exception of the os calcis, are each developed from a single centre of ossification.

Ruminants. Scaphoid and cuboid are confluent; lower surface of the astragalus is pulley-shaped.

Differences.—The tarsus of the *ox* comprises *five bones* only, the cuboid and scaphoid being ossified together to form a single *scapho-cuboid* bone. If, however, the small cubical bone, already mentioned as representing the lower end of the fibula, is to be considered as a bone of the tarsus, the number will be increased to six. The *astragalus*, elongated from above downwards, unites with scapho-cuboid by a pulley-shaped surface, somewhat shallower than that by which it joins the tibia, while posteriorly a still shallower surface of a similar kind articulates with the os calcis. The *os calcis*, longer and thinner than that of the horse, has a groove on its superior extremity for the tendon of the perforatus. The other bones occupy the same positions as in the horse. The small cuneiform is very small and pea-shaped.

Pig, has seven tarsal bones.

In the *pig* the tarsus closely resembles that of the ox. It contains, however, seven bones, as the scaphoid and cuboid remains separate, and a third cuneiform is constant. The three cuneiforms and the cuboid articulate with four metatarsals.

Dog and cat have each seven. Astragalus joins the scaphoid by a rounded head.

The tarsus of the *carnivora* is also composed of seven bones. The astragalus is remarkable for articulating with the scaphoid by a rounded *head*, separated from the rest of the bone by a constricted portion or *neck*, like in the human tarsus. The cuboid and the three cuneiforms support five metatarsal bones.

THE METATARSUS.

Metatarsals like unto carpals.

The three metatarsal bones present such a close analogy to the metacarpals, that it will be more convenient simply to state the differences between these, than to enter into a useless, because superfluous special description.

Large metatarsal is cylindrical; has a groove externally; two facets on the upper articular surface.

The *large metatarsal bone* is longer than the metacarpal, and is not, like the latter, compressed from before backward, being more cylindrical. It presents on its supero-external part a vascular furrow, which runs obliquely downwards and backwards, to gain the border of the roughened facet for the articulation of the external splint, and descends in front of this as far as its lower extremity. The superior articular surface is divided into two facets by a roughened depression for ligamentous insertion. The lower extremity is more compressed laterally, and elongated in an antero-posterior direction, than that of the corresponding metacarpal.

Internal metatarsal, two facets on its head.

The *internal splint* is at once shorter and thinner than the external. It bears on the superior aspect of its head two facets for articulation with the cuneiform bones.

External splint, two facets.

The *external* has also two facets on its upper surface, separated by a wider interval, and articulating with the inferior surface of the cuboid. Both articulate with the large metatarsal bone by means of two facets, which have between them in either case a considerable aperture.

Ruminants. Cannon is longer than in the fore-leg; pierced by a canal.

Differences.—In the *ox* we have a large metatarsal bone, with the rudiment of a second metatarsal bone attached to the postero-external part of its head. The *large metatarsal* is distinguishable from that of the fore extremity by its greater length, by its more quadrilateral form, by the greater depth of its median anterior fissure, and by a vascular canal which, from the superior articular surface, traverses the bone obliquely downwards and backwards, to open on its poste-

Small metatarsal.

rior aspect. The *small metatarsal* is a pea-like bone, articulating by a single facet, with the head of the large metatarsal bone.

Pig.

In the *pig* there are four well-developed metatarsals, the same as in the fore-limb. This animal has, however, a fifth metatarsal, very small, flattened from side to side, and articulating by a single facet behind the superior extremity of the external large metatarsal. This bone is evidently the rudiment of the great toe.

Carnivora.

In the *dog* and *cat* we find four perfect metatarsals, bearing an intimate resemblance to those of the fore-extremity, and in addition a rudimentary bone, articulated to the internal cuneiform, and, like the fifth bone of the pig, representing the hallux.

THE POSTERIOR PHALANGES.

Easily confounded with those of the fore-limb.

Os suffraginis.

Os corona.

Os pedis.

Sessamoids.

Navicular.

The bones of this region are less readily distinguishable from the corresponding bones of the fore-leg than in any region previously mentioned. The following differences may, however, be remarked: the *os suffraginis* is shorter than in the fore-limb, with its superior extremity larger, and its inferior smaller in both its diameters; the *os corona* is smaller, especially in its transverse diameter; the *os pedis* is more triangular in form; being narrowed in front, the patiloba are less prominent, the inferior surface more concave, and the lateral cartilages less ample than in that of the fore-limb; the *large sessamoids* are not so broad, but are thicker than in the fore-limb; lastly, the *navicular bone* is shorter than its analogue in that member.

Ruminants and pig.

Carnivora.

Differences.—In *ruminants*, and in the *pig*, the phalanges correspond exactly to those of the fore-leg. The same holds good in *carnivora*, with this qualification, that either the internal digit is wanting, or a small bone is attached to the rudimentary metatarsal by a band of white fibrous tissue, and to the distal end of this the second and third phalanges are appended.

CORRESPONDENCE OF THE FORE WITH THE HIND LIMBS.

General view.

It must have been already observed that a remarkable analogy exists between the individual parts of the fore and hind limbs. The arm very fairly represents the thigh; the fore-arm the leg; the carpus the tarsus; and the metacarpal the metatarsal bones. A correspondence of a no less noticeable kind exists in the supporting arches, to which the fore and hind extremities are attached. These analogies we shall shortly notice, commencing with the supporting media, and examining the various rays, in the order in which we find them arranged, from above downwards.

Supporting arches.

Scapula homologates ilium.

Coracoid represents the ischium.

Clavicle: the pubis.

Scapular and pelvic arches.—The analogies existing between these parts will perhaps be best illustrated by considering the relations they bear to each other, according to the laws of homology. The scapula and the ilium correspond in being, respectively, the pleurapophyses of the fourth cephalic and second sacral vertebræ. The iliac fossa represents the fossæ antea and postea spinata of the scapula; a longitudinal ridge, dividing the iliac fossa in the sheep, goat, and pig, substantiates this position. The glenoid corresponds to the cotyloid cavity. In solipedes we cannot trace the analogy farther. If we turn, however, to the marsupial animals, or to birds, we find the coincidence complete. The coracoid bone and the clavicle exactly represent the ischium and pubis. The coracoid is the hæmapophyses of the occipital, and the ischium that of the second sacral vertebræ. The clavicle is the hæmal arch of the atlas, and the pubis of the first sacral vertebra, their respective pleurapophyses not having been developed.

Arm and thigh.

Head.

Tuberosities.

Condyles and pulley.

Humerus twisted half round.

Bones of the arm and thigh.—Although these bones are placed so as to have a direction the reverse of each other, they correspond very closely in appearance. They have each a somewhat rounded body; the head of each is spherical, separated from the bone by a neck or constricted part; each has tubercles or trochanters, circumscribing the neck inferiorly; and the lower extremities of both are transversely elongated, and composed of condyloid and pulley-like elevations. The humerus, as noticed by Charles Martin, is twisted on itself to the extent of 180°, a circumstance of great importance as regards the proper understanding of the component parts of the fore-arm.

Fore-arm and leg.

Effect of twist in the humerus.

Muscles

Fore-arm and leg.—Very different opinions have been, and still are, entertained concerning the particular parts of the fore-arm and leg which respond to each other. Light may, however, be thrown upon the matter by the semi-revolution the fore-limb is subjected to in the humerus. Such a modification would lead us to expect a transposition of the parts composing the fore-arm, the anterior surface of the bone being turned posteriorly, and *vice versa*. Such an idea is borne out by the position assumed by the soft parts—thus: the extensor muscles of the elbow-joint are placed behind, those of the stifle in front; the flexors of the elbow are in front, those of the stifle behind: the distribution of the vascular and nervous trunks shows a similar converse arrangement. Agreeably to this general formation, we would expect to find the ulna, which is on the posterior aspect of the fore-limb, on the anterior of the hind. Such has been the conclusion of M. Martin. Taking into consideration the twisting of the humerus, and the opposite arrangement of the soft tissues in the fore and hind limbs, he finds the analogue of the olecranon in the patella, and that of the posterior sharp border of the ulna, in the anterior crest of the tibia. This conclusion is sustained by the fact that these parts are always present, and well marked in the mammalia, while the remaining parts (the fibula and lower part of the ulna) are frequently wanting, or completely blended with the tibia or radius, as in the case of rodents, ruminants, and even solidungula.

Olecranon; the patella.

Carpus and tarsus.—A very obvious correspondence exists between these joints. They hold analogous positions in the fore and hind limbs; their constituent bones are in either case arranged in two rows, and the homologues in the lower rows invariably support the corresponding metatarsal or metacarpal bones; those of the lower ranges are accordingly modified by the number of digits with which the animal is provided. In the primary typical character of these joints five bones exist in each row, an arrangement met with in the tortoise and other chelonian reptiles. In these animals, the unciform and cuboid, which in five toed animals support two digits each, have been respectively divided into two bones, the scaphoid in both joints, and the os calcis in the tarsus having also undergone a corresponding bipartite division. In the horse, which we take as the type of our domestic animals, we find seven bones composing the carpus, and six only in the tarsus. According to Mr Owen, and other eminent comparative anatomists, these bones homologate each other, in the manner following: the carpus and tarsus being respectively represented by the letters A and B. In the *upper row*:—A, Scaphoid—B, Scaphoid; A, Semilunar—B, Astragalus; A, Cuneiform—B, Os calcis; A, Pisiform—B, Point of os calcis. In the *lower row*:—A, Trapezoid—B, Cuneiform parvum; A, Os magnum—B, Cuneiform magnum; A, Unciform—B, Cuboid; when the small trapezium of the carpus, and the third cuneiform of the tarsus are present, these correspond. In reference to the bones of the lower row, it will be observed, that the middle bone in either joint supports the large metatarsal or metacarpal, as the case may be, while the smaller lateral bones articulate with the small. In the cow, which has only two metacarpal bones, the lower row consists of two bones only,

Carpus and tarsus.

Typical carpus.

Upper row.

Lower row.

whilst in the pig and the carnivora, in which four metacarpals exist, we find four bones composing the lower row.

Bones below these joints.

The metacarpus and phalanges of the fore, with the metatarsus and phalanges of the hind, limbs correspond so perfectly that any notice of their analogies would be superfluous.

THE SKELETON OF BIRDS.

Chief peculiarities only will be mentioned.

THE limits of this work prevent our entering with any degree of fulness into the description of the bones of these animals. A particular description, moreover, would be more interesting than useful, and we shall accordingly notice especially the peculiarities of the osseous system in these animals, and the more marked deviations from the mammalian type which they present. The process of ossification takes place with extreme rapidity in birds—a result of the great activity of the respiratory and assimilative processes.

Bones of the neck vary in number, from ten to twenty-three.
Those of our domestic birds.
Individual bones longer.
Articulating surfaces of the body are peculiar.
Inferior spine.
Transverse process.
Abortive cervical ribs.

VERTEBRAL COLUMN.—*Cervical Vertebræ.*—The mammalian neck has invariably seven vertebral segments, that of the camelopard no more, that of the whale no less. In birds, however, a number of additional bones are supplied; so that, as far as at present known, the cervical vertebræ in birds vary from ten to twenty-three—the latter extraordinary number occurring in the swan. The *pigeon* has 12, the *domestic cock* 14, the *turkey* 15, the *duck* 15, and the *goose* 17. The different segments are relatively longer than in mammals, and they present a remarkable peculiarity in the articulating surfaces of their bodies. Thus the superior extremity of the body presents a diarthrodial facet, convex in a vertical direction, and concave from side to side; the inferior extremity, likewise diarthrodial, has a converse arrangement. They are so locked together that the superior ones bend most freely forward, the middle ones backwards, and the lower ones again forward, producing the well-known sygmoid curve of the bird's neck. The superior spine is small, but best developed at the two extremities of this region. The inferior spine is found in the two first and two last segments, but is nearly absent in the median part of this region. The transverse process is a large blunt eminence extending along the body of the bone from beneath the anterior articulating process, terminating posteriorly in a styloid process, and pierced at its root by a vertebral foramen. The styloid process, which is an epiphysis in the young animal, is an abortive rib.

Atlas.

The atlas is reduced to a simple narrow ring, without processes, having a small cavity superiorly for the single occipital condyle, and a groove inferiorly for the conical process of the axis.*

Axis.

The axis has a large odontoid process, with a single articular facet beneath it.

Number of dorsal vertebræ, are blended together, and with the iliac bones.

Dorsal Vertebræ.—These are seven in number in the *cock* and *pigeon*, and nine in the *duck* and *goose*, generally anchylosed in the adult animal—an arrangement essential to prevent injury or discomfort from the violent exertions of the wings to which this part gives support. The transverse processes are large, and the bodies are compressed laterally, more especially as they approach the sacrum. The two or three last segments are generally covered by, and blended with, the iliac bones. The inferior spine is long, and gradually increases from the first backward. The superior spines are short, broad, flattened, and quadrilateral, becoming anchylosed by their anterior and posterior borders to those next in front and behind. The extremities of the bodies, previous to anchylosis, have the same form as in the cervical vertebræ.

No lumbar vertebræ. Fourteen sacral. Anchylosed to the innominate bones. Two rows of transverse processes.

Sacral Vertebræ.—No lumbar vertebræ can be said to exist in birds, since the fourteen segments behind those bearing ribs are anchylosed together, and are further blended laterally with the innominate bones, so as to form a single mass. On the lower aspect of this mass are seen transverse processes corresponding to the first four or five vertebral segments; in the middle four these are absent, while in the last five they again re-appear, abutting at this part against the symphysis of the ilium and ischium. Superiorly, a second row of transverse processes, on either side,

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* The great length of the neck in birds, and the connexion of its segments by diarthrodial joints, together with the articulation of the atlas and occiput, by a single glenoid cavity and condyle, ensures that mobility which is essential to the use of the bill as a prehensile organ, and, at the same time, makes up for the want of motion in the vertebræ of the back. The extensive mobility of the neck is shown by the fact that a bird can touch all parts of its body with its bill, to which may be added, that the natural position of rest seems to be with the head turned backward under the wing. The lightness of the head in birds obviates any discomfort that might threaten from the extension of the neck, an immunity farther increased by the backward position of the head when the creature rests on the ground. During flight the neck is extended, and the head carried forward into the same axis as the body, thereby carrying the centre of gravity well forward, and preventing any retardation, by head or neck, of the rapid aerial locomotion.

extends throughout the whole length of the sacrum; the first sacral is anchylosed to the last dorsal vertebral segment. The blending of these bones into one seems essential to consolidate this part for the transmission of impulses from the limbs, more especially as the innominate bones remain separate beneath.

Coccygeal not blended; their number.

Coccygeal Vertebræ.—In these the mobility of the column is again restored. Motion is, moreover, necessary in this part, inasmuch as it is destined to perform the functions of a helm, in directing the flight, whether in rising, falling, turning to the right or to the left. The segments are six in number in the cock and pigeon, and seven in the goose and duck. The last, which is much larger than the others, is flattened from side to side, turned up at its extremity, and destitute of processes and medullary canal. The others have moderate inferior spines, prominent transverse processes, and bifurcated superior spines.

Head.

Head.—The *head* is in the form of a small cone, of which the base is posteriorly, and the apex corresponds to the point of the beak. This form is highly favourable to rapid motion through the air.

Cranium is early anchylosed.

The *cranium* at once strikes the observer as being remarkable for the absence of all sutures—the whole being consolidated into a single piece. So rapid, indeed, is the progress of ossification in its component bones, that complete anchylosis has generally taken place at the time the young animal bursts the shell. In the younger bird, however, obtained from the egg while hatching, the cranium is found to be composed of occipital, parietal, frontal, ethmoid, sphenoid, and temporal bones, in the same way as in mammals.

Occipital condyle single. Fontanels in duck and goose. Parietal Frontal

The chief peculiarity of the *occipital bone* is the single condyle, placed in front of the occipital foramen, and, as already mentioned, conferring great mobility upon the occipito-altoid joint. In web-footed birds two openings just above the foramen magnum penetrate the cranium, and remain throughout life somewhat like persistent fontanels. It is primarily in four pieces, an inferior or basilar, two lateral or condyloid, and a superior. The first of these bears the condyle. The *parietal bones* are of moderate size, elongated from side to side, and become blended later than the parts composing the occiput.—The *frontal* are later than the parietal in being anchylosed into a single piece. The orbital process is not formed by this bone, but by the wing of the sphenoid.—The *ethmoid* is largely developed, though the perpendicular plate is often the only bony part. This plate forms a laminar partition between the two orbits, has a notch in its posterior margin, by which these two cavities communicate, and by which the optic nerves enter; it has further a canal near its superior border for the transmission of the olfactory nerve. The lateral convoluted laminæ are membranous, and generally attached to membranous and non-perforated plates, which form the anterior wall of the orbit.—The *sphenoid* is formed of five parts—a basilar portion, having a diarthrodial facet on each side for the articulation of the pterygoids; two orbital plates, forming the floor and the lower part of the septum of the orbits; and two cranial plates, which are later in being anchylosed to the basilar portion than the last. It gives passage to the optic nerves by a single canal, opening at the notch of the perpendicular plate, through which the nervous cords reach their respective orbits. The great alæ separate the parietal from the temporal bones.—The *temporal bones*, in the *gallinaceous* birds, have each a small tongue-like zygomatic process, frequently united to the orbital arch anteriorly. In the web-footed birds these are completely blended, and from their union a small process is sent forward to join a similar projection from the lachrymal bone, and form a true zygomatic arch, which limits the orbit inferiorly. In pigeons, both the orbital and zygomatic processes are extremely short. The temporal bones, in birds, are joined to the inferior maxillary through the intervention of two square bones (ossa quadrata).

Ethmoid.

Perpendicular plate notched for the optic nerves.

Has a canal for olfactory nerve.

Sphenoid; has two facets for the pterygoids.

Temporal, in the cock, the duck, the pigeon.

The *face* is composed of the following bones: two superior maxillary, two intermaxillary, two nasal, two lachrymal, two palatine, two pterygoid, a vomer, an inferior maxillary primarily formed of a number of pieces, and two square or tympanic bones.

The face.

The *superior maxillary* are two rudimentary bones, placed one on each side of the median part of the intermaxillary bones. Each terminates posteriorly by two processes, an internal becoming anchylosed to the outer border of the palatine, and an external articulating obliquely with the zygomatic.—The *intermaxillary*, covering the front part of the last-named bones, forms the basis of the upper half of the bill, and the floor of the nasal cavities. It is pointed and conical in the cock and pigeon, and flattened in the duck and goose. Two inferior external or mandibular processes form the hard palate, and separate the nose from the mouth; a superior or median process extends upward, and becomes wedged

Superior maxillary.

Anterior maxillary, in the cock, and goose.

Nasal bones. between the nasal bones. — The *nasal bones*, placed above the intermaxillary, form the superior, and part of the internal and external walls of the nasal cavities. They are wider inferiorly, and **Palatines.** diverge to embrace the intermaxillary.—The *palatines* bound the posterior nares inferiorly, and are of considerable size, forming a great part of the palatine arch. They join the pterygoid bones posteriorly, and the superior maxillary and palatine processes of **Pterygoids.** the intermaxillary bone anteriorly.—The *pterygoids* extend from the sphenoid, with which they unite by a diarthrodial articulation, along the posterior margin of the palatine to the inner aspect of the square bones, so that, when these bones are drawn forward, the pterygoid presses on the palatine, and raises the upper jaw.—The **Lachrymal.** *lachrymal* are moderately-sized bones, and more exposed than in **Malar.** mammalia.—The *malar* bones are small and styloid, anchylosed to the superior maxillary anteriorly, and joined to the outer aspect of the square bones posteriorly; so that, when the latter are drawn **Vomer.** forward, they assist in raising the upper jaw.—The *vomer* occupies a place analogous to that of other animals.

Lower jaw primarily of twelve pieces. The *lower jaw* is developed from twelve centres. Of these the two anterior or symphyseal are the first to unite, forming the symphysis; the two parts forming the condyles are next anchylosed to the adjacent parts; the remaining parts—namely, the angular, the supra-angular, and the two opercular or splenial portions, are anchylosed somewhat later. The angular and supra-angular join the symphyseal parts by gomphosis, while the opercular is placed on either side along this union. They are completely consolidated **Ossa quadrata.** at an early age. Each *tympanic* or *square bone* is placed like an inter-articular cartilage between the condyle of the lower jaw and **Superior articulating surfaces.** the corresponding temporal bone. On its superior aspect are two distinct transverse condyles for articulating with the last-named bone. Below this, the bone is slightly constricted, to expand again inferiorly. From the middle of its anterior part starts out a small process for muscular insertion; posteriorly, a smaller process gives attachment to the membrana tympani; from the lateral parts of its lower extremity two processes rise, the inner giving attachment to the pterygoid, and the external to the malar bones. Between the **Inferior articulating surfaces.** processes last named are two oblique, oblong convexities for articulating with the lower jaw.

Ossification of facial bones. The bones of the jaw are much later in being anchylosed than those of the cranium. The primary separation between the intermaxillary and nasal bones is long retained; and even after anchylosis takes place, the elasticity of the uniting plates allows a sufficient freedom of motion for the raising of the upper mandible.

Sternum.

Correspondence of flying powers with its size.

Inferior crest.

Its size indicates power of flight.

In pigeon, duck, and cock.

Manubrial process.

Coracoid noch.

Costal processes.

Posterior border has deep notches or foramina.

Thorax.—The *sternum* is a bone of the very first importance in birds, inasmuch as to it are attached the vast and powerful pectoral muscles that act upon the wings. Whenever length or speed of flight are wanted, these muscles must be increased, and in the same ratio must increase the sternal surface to which they are attached. The sternum consists of five segments—a median and four lateral, two anterior and two posterior. The whole are blended together so as to form a single flat bone, concave above, convex below, and prolonged inferiorly in the median line by a prominent crest or keel, which, besides affording a large surface for muscular attachment, confers great strength upon the bone. This crest is modified according to the requirements of the animal, and according to its greater or less development may be inferred with certainty the flying powers of the bird to which it belongs. Thus, in the swift-flying pigeon it is largely developed; in the duck and goose it is somewhat less; while in the cock, which flies little and badly, it is comparatively small. The anterior border of the bone has a slight eminence in the median line called the manubrial process, and on each side of this a notch for the coracoid bone. The lateral borders bear a number of double facets for articulation with the ribs. These are separated from the anterior border by two prominent angles called the costal processes. The posterior border varies with the description of bird. Thus, in the duck and goose it is straight, with two deep notches in its lateral parts nearly closed posteriorly; in the pigeon, these notches are closed, and converted into foramina; in the cock, on the other hand, we have four very deep and wide notches, the two larger internally, and the two smaller externally, all closed, in the fresh state, by membrane. From the above-mentioned arrangement, we have in this bird, besides the central continuation of the sternum, four flat processes, with slightly expanded extremities. Of these the two internal are long and slender, the two external short, and somewhat broader. The number and depth of these notches weaken the sternum, and, like the diminution of the inferior crest, afford proof of weakness in flight.

Ribs in cock and duck.

The *cock* and *pigeon* have each seven ribs, and the duck nine. These unite with the vertebræ superiorly, the same as in mammals, but are prolonged inferiorly by bones in place of cartilages, as in have processes.

the latter animals. The heads of the ribs do not articulate with the intervertebral spaces, but with a cavity near the anterior extremity of the corresponding vertebra. From the posterior border of each true rib, about its middle, a flat process projects upward and backward, responding by its free extremity to the external aspect of the rib immediately behind. These processes, which are generally wanting in the first and last ribs, seem designed to give greater solidity to the walls of the thorax. They have separate centres of ossification.

Inferior ribs.

A series of small bones, or inferior ribs, representing the costal cartilages of mammals, join the ribs by diarthrodial articulations, and articulate with the sternum by double facets, furnished with two synovial capsules. In the first ribs they are generally wanting, as these do not join the sternum. In the others, they are powerful and rounded long bones, having a direction downwards and forwards between the points above-named. Those belonging to the last pair of ribs generally unite with those next in front, and not directly with the sternum. In the cock, these last pair do not unite with the superior ribs, but homologate the tendinous intersections of the rectus.

Shoulder typical.

Scapula.

Coracoid.

Furcula or clavicles.

At the union of the three bones is a hole.

Anterior Limbs.—The *shoulder* is composed of three bones—the scapula, the coracoid, and the clavicle; the last of these, becoming anchylosed to that on the opposite side, forms a single bone called the furcula, or merrythought.—The *scapula* is an elongated, narrow, and somewhat flattened bone, placed on the lateral aspect of the thorax, in an antero-posterior direction. It bears no trace of a spine; and at its anterior extremity, which forms part only of the glenoid cavity, it joins the coracoid and furcula by intervening fibro-cartilage. —The *coracoid* is a long prismatical bone directed from above downwards and backwards, to articulate by its flattened inferior extremity with the diarthrodial surface on the anterior border of the sternum. Its superior extremity uniting with the scapula, forms part of the glenoid cavity. This bone is short and powerful in birds capable of strong and continuous flight, but long and slender in slow-flying birds. —The *furcula*, or *merrythought*, represents the two clavicles joined together inferiorly at an angle more or less acute. It is accordingly V or U shaped, and each of its branches extends from the point of union upwards, forwards, and inwards to the root of the corresponding wing. The superior extremity of each branch joins the coracoid and clavicle inside the glenoid cavity, leaving between the three bones an opening for the passage of the levator muscle of the wing.

This elastic bone contributes, along with the coracoid, to prevent the approximation of the wings when the pectoral muscles are powerfully contracted in flight. Its shape corresponds to its requirements; thus, in birds of rapid flight, as in the pigeon, and to a lesser degree in the duck, the merrythought is short, strong, and rounded at the junction of the two branches; while in slow unwieldy fliers it is long and slender, with its two branches joined at an acute angle. This last arrangement must necessarily greatly lessen the power of reaction when the two branches are pressed together.

Its form varies with flying abilities.

Humerus.

The *humerus* is long in the goose and duck, of median length in the cock, and very short in pigeons. It joins the glenoid cavity by a transversely oval head, beneath which is an aërial foramen. The head is further enlarged by two lateral crests, an internal and an external, for muscular attachment. The lower end is composed of an internal large spherical part for articulating with the ulna, and an external oblong part for the radius, extending some distance on the anterior aspect of the humerus.

Fore-arm. Ulna largest.

The *ulna*, much the largest bone of the fore-arm, has a short olecranon. Both *radius* and *ulna* are long hollow bones, united firmly at each extremity by ligamentous connections, but having their shafts separate. The union is sufficiently firm to prevent the actions of pronation and supination; while, at the same time, a sufficient amount of gliding is permitted to allow a depression of its posterior border while the wing is being raised, and thus to prevent hindrance from the air. It may be accepted as a general rule, that the better the flying powers are, the longer will be the bones of the fore-arm.

Carpus.

There are only *two carpal bones*, designated the radial and the ulnar, from the bones to which they correspond. These are so constructed, that flexion and extension are impossible, while slight abduction and adduction are allowed.

Metacarpus.

The *metacarpus* consists of two long bones, united, like those of the fore-arm, by their extremities, but separate at their median part. The larger corresponds to the radius.

The *digital region* is represented by *two fingers* and a *rudimentary thumb*. The *larger digit* is composed of two short phalanges, supported on the distal extremity of the larger metacarpal bone. The *second finger* is represented by a small rudimentary phalanx, supported by the smaller metacarpal bone, and closely bound, throughout its whole extent, to the first phalanx of the larger digit.

Large digit.

Small digit.

Abortive thumb.

The part corresponding to the thumb consists of a single phalanx of a styloid form, supported by a small tubercle on the superior extremity of the large metacarpal bone.

The metacarpus and phalanges attach the great quill-feathers; the fore-arm, the smaller or secondary; while the tertiary or scapular feathers are supported by the arm-bone.

Ilium.

Ischium

Pubis

No symphysis pubis.

Posterior Limbs.—The *innominate bones* are large and strong, primarily separable into three bones on each side—an *ilium*, an *ischium*, and a *pubis*. The *ilium* is a flat bone, concave internally, firmly anchylosed to all the sacral, and the two or three last dorsal vertebræ. It unites with the ischium behind the ischiatic notch, converting that into a foramen. The *ischium*, fixed along the lower margin of the ilium, is a broad, powerful bone, closing the pelvis at the side. The *pubis*, placed along the posterior border of the ischium, is thin and elongated, and, with the bone just named, forms an obturator foramen of variable size. The *pubic bones* turn toward each other posteriorly; but in place of uniting, as in mammals, they, on the contrary, have a wide intervening space highly favorable to the passage of eggs. Below the cotyloid cavity each joins the ischium in forming the obturator foramen. The bone is perforated by a remarkable opening in the depth of the cotyloid cavity.

Femur.

The *femur*, a long and powerful bone, articulates above with the acetabulum, and below with the tibia, fibula, and patella. It is of great strength in the cock and other walking birds.

The leg has patella, tibia, and fibula

The *leg* is formed of a broad thin *patella*, a very long *tibia* joining the metatarsal bones by two condyles, with an intercondyloid notch, and a small *fibula* anchylosed throughout to the tibia, but not extending to the lower extremity of that bone. It articulates above with the outer condyle of the femur.

No true tarsus

Abortive os calcis.

There are no bones interposed between the tibia and metatarsus which can be looked upon as representing the tarsus. The *os calcis* is, however, represented by a small bony nodule, existing in a mass of fibro-cartilage, which plays over the posterior aspect of the lower extremity of the tibia. The astragalus likewise exists, but is anchylosed to the metacarpus.

Metacarpal bone;

has three pulleys inferiorly.

Spur process in the cock.

There is only one *metacarpal bone*, articulating above with the tibia, and having at its lower extremity three pulleys for the support of the three anterior digits. In the cock it has, on the postero-internal aspect of its middle part, a conical eminence projecting backward for the support of the spur. Another prominence behind its superior extremity represents a second metatarsal bone anchylosed to the principal one.

The common domestic birds possess *three anterior* and *one posterior digit*. The three anterior are attached to the pulleys on the lower end of the metatarsal bone; the posterior is united by fibro-cartilage to the postero-internal aspect of the same extremity. The number of phalanges in each digit increases in a constant ratio from within outward; thus, the posterior has two, the antero-internal three, the median four, and the external five. These are constructed in a manner similar to those of the carnivora, and each distal phalanx sustains a claw in the same manner. The proximal segment of the posterior digit is generally looked on as a metatarsal bone.

Four toes.

Number of elements increase from within outward.

Arranged like in the dog.

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